
DOE/OR/21548-411
CONTRACT NO. DE-AC05-86OR21548

CONCEPTUAL DESIGN REPORT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE, VOLUME II TECHNICAL INFORMATION DOCUMENT BOOK 2 OF 5

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JANUARY 1994

REV. 0



U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Printed in the United States of America. Available from the National Technical Information Service, NTIS, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

NTIS Price Codes - Printed copy:	A01
Microfiche:	A99

**Conceptual Design Report, for Remedial Action at the Chemical Plant Area of the
Weldon Spring Site, Volume II Technical Information Document**

Book 1 of 5 contains Sections 1-5

Book 2 of 5 contains Sections 6-12

Book 3 of 5 contains the figures for all sections

Book 4 of 5 contains the tables for all sections

Book 5 of 5 contains Appendix A, Unpublished Documents, and Appendix B, Acronyms

Weldon Spring Site Remedial Action Project

**Conceptual Design Report, for Remedial Action at the Chemical Plant Area of the
Weldon Spring Site, Volume II Technical Information Document**

Book 2 of 5

Revision 0

January 1994

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for the

**U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548**

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6 SITE OPERATIONS AND FUNCTIONS

6.1 General

The construction and operation components of the designs (detailed in Section 5) include similar groupings of designs: general, disposal cell, treatment and processing, and site closure. Steps required for construction, sequencing of activities, and methods of operation (including such items as interim disposal cell cover during winter shutdown and chemical stabilization/solidification (CSS) treatment plant operation) are provided for the site conceptual designs. The disposal cell's expected long-term performance is detailed separately in Section 8. The final segment of Section 6 lists the general contracting requirements for the remediation effort.

6.1.2 Waste Removal

6.1.2.1 General. The operations related to waste removal are both location and material specific. The removal methods selected in Section 5.1.2.2, Removal Plan, and the design criteria identified in Section 5.1.2.3, Design Criteria and Specifications, form the basis of the removal conceptual design. Water control during removal is addressed in Section 6.1.6 and in *Supporting Study 15, Excavation and Water Control Plan* (Ref. 109). The activities required during waste removal operations can generally be grouped into three categories: (1) site preparation, (2) waste removal, and (3) site restoration.

Site Preparation

Prior to removal of the waste, several preparatory activities are necessary. These activities include:

- Construction of access roads and access control facilities, and installation of local surface water, erosion, and sedimentation control systems. These systems will be integrated with the overall site drainage system addressed in Section 6.1.6.
- Installation of temporary personnel and equipment decontamination facilities. The necessity of these facilities will be ascertained during Title II Design.

- Preparation of a temporary material staging area, if necessary. It may not be feasible or desirable to remove and haul material directly to the final destination.
- Installation of area security such as fencing and gates around work zones. This requirement will be evaluated during Title II design.
- Clearing and grubbing of vegetation preparatory to removal of in situ contaminated materials.
- Abandonment and relocation of wells within the areas where in situ contaminated materials will be removed.
- Removal of surface and known buried debris prior to or during removal of in situ contaminated materials.
- Relocation of utilities including underground water system and overhead power lines if they are present within the work zone and interfere with materials removal.

Waste Removal

Activities ancillary to removal include controlling radon and particulate emissions, dewatering, collecting and handling surface water runoff, handling unexpected buried debris, and decontaminating equipment to prevent cross contamination.

The applicable characterization data for the removal area will be used to depict the contamination types, locations and depths. Removal zones will be established within the area, and the removal will proceed based upon a prescribed sequence. Once the material has been removed to a predetermined location, samples and measurements will be taken within the area to verify that all contaminants have been removed. Removal will continue until all contaminated material has been removed.

Site Restoration

Site restoration activities include removal of all temporary facilities, the earthwork needed to establish design grades, and revegetation of the site to control erosion and possibly to improve aesthetics.

Equipment decontamination is not specifically addressed for each area discussed in Sections 6.1.2.3.1 through 6.1.2.3.7; specific equipment decontamination requirements are in place at the Weldon Spring site. However, some general observations can be made. Provided that designated clean areas are not affected, decontamination will consist of scraping equipment with shovels to remove visible contaminants. If clean areas are involved, established Weldon Spring Site Remedial Action Project (WSSRAP) equipment decontamination procedures will apply.

6.1.2.2 Waste Characterization. Selected removal methods are a function of material physical characteristics including material type, size and density; moisture content; and location. The subsections below describe the physical characteristics that will affect removal operations for the following materials:

- Soils.
- Raffinate pit sludge.
- Foundations and underground utilities.
- Stockpiled material.

6.1.2.2.1 Soils. The primary physical characteristics affecting removal include classification, surface area, depth, and moisture content. The soils to be removed can generally be classified as topsoil, earth, and rock. Topsoil is usually removed first and stockpiled for area reclamation use if it is uncontaminated. Earth can be readily removed using conventional equipment. Surface area is important because some equipment, such as scrapers, is more suited to larger tracts.

Depth is also important to equipment selection because particular equipment, such as backhoes, is more suited for removing of material at deeper depths. The regulations (29 CFR Part 1926, Subpart P) address requirements for all open excavations made in the earth's surface including trenches. In general, the regulations state that workers in an excavation must

be safeguarded by an adequate protective system unless the excavation is (1) entirely in stable rock or (2) less than 5 ft in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

Acceptable protective systems include sloping and benching of sidewalls to prevent cave-in or installation of engineered sloping and bracing and benching systems. Sloping and benching requirements, as described in the regulation, are based in part on the following classifications: (1) stable rock or (2) type A, B or C soil. Material type determines the sloping and benching requirements for the excavation sidewalls. The exception is for depths exceeding 20 ft; in which case a slope stability analysis is needed to determine slope angles.

Material moisture conditions also affect equipment selection. Wet conditions may require tracked equipment or the addition of stabilizers so that equipment weight can be supported. Dry conditions will result in the need for dust control and may cause the suspension of removal activities.

6.1.2.2.2 Raffinate Sludge. The primary physical characteristics affecting removal include moisture content, particle size, density, degree of consolidation, and topography. Moisture content is an important factor when evaluating material suitability for removal by dredge or by more conventional equipment. The raffinate sludge is extremely fine-grained, and particulate emission control is an important factor. It is also likely that larger-sized materials (debris and rocks) of various densities may be present at discrete locations within the pits; the selected equipment must be capable of removing these materials. The degree of consolidation of the in situ material is important because it will affect the effort required to remove the material as well as determine the material sizes resulting from the removal action. Topographic data is necessary to develop the material removal plan; more accurate data concerning sludge thickness will help ensure that the underlying clay bottom remains undisturbed during material removal. The topographic data will also be used to assess whether the sludge needs to be redistributed prior to removal so that an adequate water cover can be maintained for emission control.

6.1.2.2.3 Foundations and Underground Utilities. The physical characteristics affecting foundation removal include type and design. Foundation type will dictate removal methods; concrete may be broken up into manageable sizes with a hoe ram attachment, whereas steel pilings will require removal with a crane equipped with a hydraulic vibrating pile driving

hammer and possibly torch cutting. Foundation design is important because reinforcing bar size, type, and size including depth were all determined based on the amount of loadings that needed support. Foundations that supported larger loadings require more effort to remove because reinforcing bars will be a larger diameter, possibly requiring torch cutting. Foundations may be thicker and, at deeper depths, may possibly require more effort to break and more extensive excavation.

Important underground utility physical characteristics include type, size, and depth. Utility type will affect the methods used to break the pipes at joints and in mid-sections; it may also affect whether removal must be performed under wet conditions as may be the case for asbestos transite pipe.

Utility size will affect whether the equipment used to excavate the soil to reach the pipe can also be used to remove the pipe, or whether supplemental equipment such as a crane is necessary. As described in Section 6.1.2.2.1, depth of excavation is an important consideration to ensure compliance with 29 CFR Part 1926, Subpart P. Depth will also factor in the selection of removal equipment size and type.

6.1.2.2.4 Stockpiled Materials. Stockpiled materials include soils, rubble, metals, and containerized waste. Factors affecting removal include material size, shape, and density. Material size and shape affects equipment type; material density will determine equipment size.

6.1.2.3 Removal Operations. As described in Section 5.1.2, Waste Removal, the diverse nature of the waste materials requires removal plans specifically suited to the waste types and resident locations. Similarly, removal operations must be developed to suit specific conditions; schedule constraints and equipment decontamination needs must be considered as well. Removal operations are discussed for the following material types:

- Contaminated soils.
- Foundations and underground utilities.
- Temporary storage area (TSA) waste.
- Raffinate pit sludge.

- Material staging area (MSA) waste.
- Vicinity property soils.
- Water treatment plant waste.
- Other waste including mulch, asbestos-containing materials (ACM) and Ash Pond spoils pile soils.

The equipment selected in Section 5.1.2 to provide workable and efficient waste removal systems for the specific waste types and locations is identified in the subsections below.

Many factors are involved in estimating the equipment and labor requirements needed to remove material. Important factors include the material physical characteristics, type of waste, volume to be moved, desired delivery rates, haul distances, weather conditions, road limitations, and operating schedules. Manpower and equipment operating requirements such as time to load, transport, unload, and return to loading site are estimated using haul cycle evaluation methods. Equipment and labor requirements, including productivity rates, have previously been analyzed. These production rates are reported in the subsections that follow.

6.1.2.3.1 Contaminated Soils. Contaminated soils must be removed from several areas at the chemical plant. Each area is discussed separately below. Removal of contaminated soils from vicinity properties is addressed in Section 6.1.2.3.6.

Ash Pond Area. This is a large area with contaminated soils ranging in depth from 0.5 ft to 2.5 ft. Because of the large surface area and relatively shallow depths of contamination, scrapers could be used to efficiently excavate these soils. Other waste materials may be stockpiled in this area before the soils are excavated, pending the construction of the disposal facility. If this is the case, the area cannot be excavated until well into the remediation process. Because of the short haul distances to the disposal cell, less than 1,500 ft, scrapers could also be used to transport the material. A small portion of the Ash Pond area is covered with water that will require removal prior to excavation. Once dewatered, the underlying soil should dry sufficiently to allow scraper operation. Subsequent investigations could indicate the presence of buried debris or other site characteristics that would preclude the use of scrapers. Backhoes could then be used for material removal.

Frog Pond Area. This area is composed of a 4-ft-deep contaminated area and a long, slender area with contamination to a depth of 1 ft (refer to Figure 1-3). The larger area is amenable to excavation (after dewatering) and removal using a backhoe. A scraper may also be appropriate; however, the depressed pond area and potential wet conditions could preclude its use. Either a front-end loader or a backhoe would be suitable for excavating the long, slender area. Because the narrow portion is along a drainage channel, the backhoe may be a better selection.

North Dump Area. This area, shown in Figure 1-3, contains two zones of contamination with contaminated soil at depths of 0.5 ft and 3 ft. This area is covered by small-diameter trees (approximately 6-in. diameter). Once cleared, the soil can be removed and transported using scrapers. Buried debris in this area may impact the type of equipment best suited for removing this soil. Depending on the extent and type of buried debris, backhoes may be a more appropriate equipment choice.

South Dump Area. The south dump covers a large surface area relative to the depth of contamination (0.5 ft). Scrapers would be well suited for removing and transporting this soil, especially considering that the area is adjacent to the Ash Pond. However, buried debris in this area will impact the type of equipment best suited for removing this soil. A geophysical survey (Ref. 110) indicates the presence of buried debris throughout the south dump. Backhoes may be a more appropriate equipment choice.

Raffinate Pit Soils Area. The area east of Raffinate Pit 3 is the preferred site for the treatment facility. It may be necessary to remove this contaminated soil early in the remediation process to provide a clean area for plant construction. Scrapers would provide adequate removal of the relatively shallow (1 ft) waste. If the soil in this area does require removal early in the cleanup process, the soil may need to be transported to and stockpiled in the Ash Pond spoils area, which is well within efficient scraper operating distances.

Drilling data from locations adjacent to the northeast corner of Raffinate Pit 3 indicate the presence of water at shallow depth. The presence of damp soil during excavations hinders the effectiveness of the excavation equipment. If the soil does not dry once exposed to the atmosphere, scrapers may not be useful in this area. Pending additional sampling, contamination depths may also preclude the use of scrapers and other similar types of equipment.

Raffinate Pit Clay Bottom and Dikes. After removal of the raffinate sludges, the clay bottom material will also require removal. An estimated 3 ft of underlying liner material will need to be excavated. Approximately 1 ft (top third) of this material will be delivered to the waste treatment facility, and the remaining 2 ft may be transported directly to the disposal facility. While some of the clay bottom will probably be removed during the sludge removal, the remainder will require excavation after the sludge and cover water are removed. This remaining material can be dozed into piles and loaded into trucks using front-end loaders.

As described in Section 5.1.2, the first lift may be too wet and soft to support heavy equipment. This situation may be further complicated if the time between water removal and clay bottom removal is not sufficient to allow the material to dry adequately. If this is the case, temporary access roads could be constructed across the pits. These roads would allow a long-boom backhoe to reach all clay bottom material and place it into trucks for delivery. Alternatively, in-place treatment by spreading binder and disking to mix the binder and clay, may also be an appropriate method for treatment of the clay bottom material.

The contaminated portion of the dike will be removed using a backhoe. The backhoe will operate from the top of the dike and from the pit bottom once the raffinate sludge and water are removed.

Soil Within Chemical Plant Area. The contaminated soil in this area occupies numerous, relatively small areas in and around the chemical plant buildings. Generally, the contaminated soils are shallow, ranging from 0.5 ft to 2 ft in depth. Because these soils are interspersed among the building foundations and roadways, the work areas will be small and confined. To effectively complete the excavation and removal of this shallow waste, a tracked-type tractor (bulldozer) could push the waste into piles for subsequent handling. Within this general area, two areas contain contaminated soils at depths of 4 ft and 11 ft; this material would be removed most efficiently using a backhoe.

Within this area, clean soils are interspersed with contaminated soils. Removal is also complicated by the presence of building foundations and underground utilities which also must be removed. Characterization data from soil sampling programs and the proposed foundation and underground utility physical survey will be used to define the contaminated and clean soils as completely as possible including defining the potential for contaminated soils beneath the building foundations and surrounding the underground utilities.

All defined contaminated soils should be removed from this area prior to removing the foundations and utilities. Once removed, a verification program would be conducted. These areas would then be certified as clean. Soils that have been designated as clean should be removed in defined stages and quantities and temporarily stored at identified staging areas. A sampling program should be developed to verify the materials are clean. Verified and suitable clean soils could then be used as a clean material. Soil excavation associated with foundation and underground utility removal would also proceed similarly to the procedure described above. Defined contaminated and clean materials would be removed separately and in stages. A verification program would be conducted to verify materials as clean or dirty. Definition of clean and contaminated materials; development of a verification program; and removal sequencing and staging will be developed during Title II design.

Some of the contaminated soils within the chemical plant building area are encountered within the foundations and underground utilities. Production rates will vary depending on contaminated material locations.

The removal of the contaminated materials described above will create holes from 0.5 ft to over 6 ft deep. These holes will require backfilling to allow suitable drainage and to produce an acceptable topography. The rough irregular surfaces that result may require shaping to provide a suitable surface for backfilling of disposal facility foundations soils. Any over excavation that may be required to ensure stability of the disposal facility footprint is discussed in Section 5.2.4.

Backfills in areas outside the disposal facility footprint will not require sufficient stability to support the cell or other structures. The compaction requirements, and therefore the equipment types and operating methods, will be far less restrictive than for the area within the disposal facility (see 5.2.4) footprint. Compaction to approximately 90% of dry density as determined by the standard Proctor (American Society for Testing and Materials [ASTM] D698) will be acceptable and can be achieved by placing the fill materials in controlled lifts, approximately 1 ft in depth, and then compacting with common compactors such as a sheepfoot or vibratory roller. For small areas, acceptable compaction could be achieved by running over the fill with the placement equipment (front-end loader, motor grader).

The backfill material may have to be obtained from off-site borrow sources or possibly from excess on-site soil made available during the cell construction or other clean excavations.

These areas should be backfilled soon after excavation to reduce water buildup, to control erosion, and to prevent possible contamination.

6.1.2.3.2 Foundations and Underground Utilities. Current plans call for breaking the concrete slabs, foundations, and footings into relatively small pieces (3-ft nominal) that can be easily handled with loading and hauling equipment. No hand rigging, cranes, or individual piece work is anticipated. A variety of concrete cutting equipment including shears, hoe ram attachments, and concrete saws will be applicable.

Removal of underground piping and utilities will require digging a number of trenches. A backhoe is well suited to digging trenches and can also be used to separate the clean soil from any contaminated soil adjacent to the pipes.

Underground piping and sewers will be exposed using backhoes. If all contaminated surface soil is removed prior to trenching, the clean soil between the surface and the underground utility line could be stockpiled next to the trench. Any contaminated material adjacent to the pipe can then be removed for disposal. It is assumed the buried pipe will be uncovered and removed in its manufactured lengths. Following excavation and removal of all contaminated soil, the trench may be filled and compacted with clean earth from the adjacent stockpile and from borrow sources. Depending on the depth of the trench, the side slope will be determined by applicable regulations so that workers may enter the bottom of the trench to collect samples.

Building footings and foundations range from 4 ft to 8 ft in depth and include a substantial number of sumps, equipment pads, and piers up to 25-ft deep. The depth of the underground utilities ranges from 3 ft to 17 ft and possibly deeper. Removal of the contaminated soils, building foundations, and underground utilities will leave trenches and holes throughout the cell footprint area. The disturbed area will potentially require backfilling followed by compaction to strict specifications as described in Section 6.2, Disposal Facility.

Removal of the foundations should be structured and sequenced in the reverse order of general accepted construction practices for installation of concrete foundations. The lowest or deepest foundations, spread footing, equipment pit or piers are generally installed first, followed by the placement of building floor slabs, access ramps to buildings, dock slabs. Roads are usually the last items installed.

Figure 6.1.2-1 illustrates typical foundations that may be encountered at the chemical plant site. The following discussion describes foundation removal. To facilitate discussion, the following removal categories have been established:

1. Foundation interiors. Items within the physical perimeter of the building foundation grade beams and spread footings.
 - a. Shallow excavations. Depths ranging from the existing at grade surface to 4 ft below existing grade; includes removal of floor slabs, floor trench drains, and floor sumps.
 - b. Intermittent excavations. Depths ranging from 4 ft to 20 ft below existing grade; includes underground tunnel structures, equipment pits, utilities, and spread footings.
 - c. Final excavations. Depths over 20 ft below existing grade, including equipment pit walls, slabs, sumps, and piers; engineered soil stability analyses are required by regulations.
2. Foundation exteriors. Items outside the building perimeter to the edge of roads. Most of the items to be removed within this physical boundary should require only shallow excavation; however, it is probable that some intermittent, deeper excavations may be required.

Foundation interiors should be removed first, so that existing docks, access ramps, and roads can be used to stage, size, and sort materials encountered during excavations including any underground pipes and utilities. Using the existing access roads and ramps that connect to the existing road systems will help prevent the potential cross-contamination of clean soils during building interior removal actions.

Building interior removal would begin by removing building floor slabs including all poured-in-place containment curbs, equipment pedestals, floor trench drains, isolated floor sumps, and column bearing pads, if encountered. Removal would be initiated at the weakest point of the floor slab, the construction joints. Two possible removal alternatives are described below:

- Break the floor slabs at the existing construction joints to expose the tie reinforcing. Cut reinforcing using torches or shears.
- Saw cut floor slabs at the constructions joints which will sever the reinforcing.

The slabs would then be broken into required dimensions to facilitate loading and transport. Once the shallow excavation is complete, the intermittent deeper excavation would be initiated. The removal sequence would generally be as follows:

- Building grade beams.
- Building perimeter spread footings.
- Pipe chases or air shaft tunnels, equipment pits, and column piers.
- All in-service process, sanitary and storm sewer pipes, water pipes, and electrical conduits would need to be retained and protected.

An important consideration is to retain and protect all stand pipes during removal activities. Documentation may not exist for these structures since subsequent piping may have been added. The location must be clearly identified so that underground utilities can be marked and removed. Care must also be taken during removal to prevent the inadvertent burial of adjacent structures during ongoing excavations.

Once the intermittent excavations are completed, the final foundation excavations would be accomplished as follows:

- Shoring or sheet piling of deepest excavations as determined by engineering soil stability analysis.
- Mass excavation of total building area to remove all remaining structures and piers as determined by the engineered soil stability analysis.

Foundation removal can be phased and staged to coincide with the removal of as yet unknown underground utilities and contaminated soil to minimize material handling.

Foundation exterior removal would begin once interior removal is completed. Some shallow exterior structures may have been removed at foundation interior perimeters because of close proximity. The removal sequence for the remaining foundation structures would generally be as follows:

- All shallow foundations for aboveground equipment, tanks, and pipe rack support bases.
- All remaining below ground storage tanks.
- All sanitary and process sewer structures such as septic tanks and manholes.
- All remaining building docks, access ramps, retaining walls, and below-grade piping and conduits.
- All surface drainage structures; surface storm water drainage structures should be maintained where possible to provide discharge points for excavation dewatering.

The last phase would be the removal of roads and the underground piping located underneath. Once the roads have been removed, these underground facilities could be removed during excavations required to establish the disposal facility subgrade.

6.1.2.3.3 Temporary Storage Area Waste. Figure 6.1.2-2 shows the proposed TSA stockpile arrangement (Ref. 111). Actual stockpile arrangement may differ from the proposed plan; however, the basic removal requirements will not be affected significantly by deviations.

Several equipment types will be necessary to remove material from the TSA stockpiles. Backhoes, dozers, front-end loaders, and cranes will be needed. The removal methods used will depend on both material type and location. Figure 6.1.2-3 illustrates three potential removal methods for the various stockpiled materials.

Scenario 1. Structural debris, equipment, and process vessels will be removed using both front-end loaders and cranes. The selected equipment will depend on material size, weight, and

maneuvering room available. Space constraints may preclude use of the front-end loader if other stored material is in close proximity to the stockpile.

Scenario 2. The chipped clear and grub material is best removed using a front-end loader.

Scenario 3. Removal of the quarry sludge, rubble, soil, and nitroaromatic-contaminated material will need to be closely coordinated with treatment facility processing and waste placement requirements. These requirements will ultimately dictate how the material will be removed as described in Section 6.3, Treatment and Processing. Regardless, backhoes, dozers, and front-end loaders will be needed to remove material. Backhoes will be needed if removal is accomplished by working on top of the stockpile. Dozers could be used to remove the layer of quarry sludge to minimize mixing of the sludges and underlying soils. Front-end loaders would be used if material is removed by working from the toe of the slope. Potential removal alternatives include:

- Separate removal of quarry pond sludge - use dozer to push in piles for a front-end loader to pick up.
- Separate removal of nitroaromatic-contaminated material; remove before quarry soils and rubble - use backhoe working on top of stockpile.
- Remove material on an as-needed basis; use combination of backhoes and front-end loaders, respectively working from top and bottom. Selection is based on material location. It is anticipated that the majority of the rubble will consist of rock and concrete with some miscellaneous debris. The rubble may be removed by either a wheeled front-end loader or by a tracked backhoe equipped with a grapple. The front-end loader would be used for removing material from the stockpile toe. The backhoe with grapple would be more suitable for removing material when operating from the top of the stockpile.

6.1.2.3.4 Raffinate Pits. Based on the opinion of a commercial dredging company, a dredge may be used to remove the sludge from the raffinate pits. The dredged sludge would then be pumped to the dewatering facility for processing at the waste treatment plant. Using a barge-mounted dredge with a cutter-head attachment, the boom would be lowered below the

water level into the sludge to cut and mix the sludge. The barge-mounted pump would then force the material through a flexible pipe to the sludge dewatering facility. Equipment will be decontaminated at project completion and released, provided release criteria are met. A salvage value will be agreed upon prior to project start to reimburse the owner should the equipment need to remain on site. Operating uncertainties are further addressed in Section 6.1.2.4; a pilot-scale test is needed to confirm dredging feasibility.

Because this method requires maintaining a water cover over the sludge, the coordination of water movement among the pits and delivery to the site water treatment plant (SWTP) is important.

Trains 1 and 2 of the SWTP will operate continuously at 50 gal/minutes and 35 gal/minutes (gpm), respectively. Train 1 has a nominal capacity of 80 gpm, but 30 gpm has been reserved for treatment of water from the TSA surface water detention basin. Water from Raffinate Pits 2 and 4 can be treated by both SWTP Trains 1 and 2. Water samples from Raffinate Pits 1 and 3 have indicated elevated levels of nitrates. Water may be restricted to treatment using Train 2 which has denitrification capabilities. Section 6.1.2.5 addresses water removal sequence and scheduling.

Building debris and other rubble were previously dumped into Raffinate Pit 4. This material will require characterization and removal once the water and sludge have been removed or in conjunction with sludge removal. Working from the top of the dike, the rubble could be removed using a backhoe and placed into trucks for delivery to a designated temporary storage area or directly to the disposal cell.

Following removal of the sludges, water, clay bottom and underlying soils if required, the raffinate pits can be backfilled to provide suitable drainage conforming to the site drainage plan. If the present dikes are not contaminated, this material could be used as backfill. Spreading the dike material with dozers would be an efficient and economical method of distributing this material. Because of the relatively low bearing pressure of a tracked dozer, additional compaction equipment would probably be required to meet a 90% of dry density as determined by modified Proctor (ASTM D1557). A minimum of 90% of dry density as determined by modified Proctor is recommended because it is considered the acceptable minimum for a controlled fill and will prevent subsidence that could peripherally impact the disposal cell. Additional backfill material would likely be required to achieve the desired ground

contour and to provide a suitable medium for vegetation growth above any existing rock used to face the dike.

6.1.2.3.5 Material Staging Area Waste and Debris. As shown in Figure 6.1.2-4, the MSA stockpiles are segregated into the following categories of materials:

- Shreddable.
- Nonshreddable.
- Stainless steel.
- Structural steel and railroad rail.
- Wood.
- Copper conduit with wire.
- Copper.
- Trash and miscellaneous nonmetals.
- Miscellaneous nonfriable asbestos.
- Nonfriable asbestos siding.
- Miscellaneous aluminum.
- Process piping.
- Intact.

Figures 6.1.2-4 and 6.1.2-5 show typical plan and section views of the MSA stockpiles. The figures indicate maximum stockpile height and side slopes. Removal will be accomplished using a combination of cranes, forklifts, and front-end loaders. Material removal selectivity has been preserved by providing roadways. Removal equipment would generally begin at one end and work toward the opposite end. It is possible that these roadways will be used for material storage. If so, more extensive coordination will be required to access specific material types for removal. For example, a roadway would need to be cleared by removing material to access a specific material location.

6.1.2.3.6 Vicinity Properties. Removal of the vicinity property soils is similar to the removal of the site contaminated soils, except that the surface areas and contaminated material volumes are significantly smaller. Figures 6.1.2-6 through 6.1.2-13 show the contamination limits for Army Properties 1, 2, 3, 5, and 6 and Busch Properties 3, 4, and 5 (Ref. 112). Table 5.1.2-14 summarizes all vicinity property areas that are contaminated. Each area respective to removal is discussed below.

Army Property 1. The sampling data indicate that three areas have U-238 contamination: 18,000 sq ft in the southeast corner of the wooded field, 1,200 sq ft along the railroad track east of the wooded field, and 1,000 sq ft along the drainage ditch. The total volume of contaminated material is approximately 1,165 cu yd.

The contamination in the open area and associated drainage ditch is presumed to be the result of a mound of buried scrap metal, wood slag, and other debris. The contamination along the railroad track may be a result of yellow cake spills or may have resulted from washing of rail cars.

The depth of contamination in the wooded field ranges from 6 in. to 48 in. The deepest contamination is under the 2,800 sq ft contaminated mound of buried debris. The shallower contamination is located in the north and west sectors, downhill from the mound.

The small drainage ditch flowing from the contaminated southeast corner of the wooded field ranges in width from approximately 2 ft to 15 ft, with an average width of approximately about 5 ft. Contamination levels are highest in the southern (upstream) reach of the ditch and decline greatly as the ditch fans out.

Contamination within the ditch adjacent to the railroad ranges from 12 in. to 30 in. in depth. The ditch is about 4 ft x 300 ft x 30 in. deep.

Army Property 2. The soil sampling data indicate that a 0.3-acre area north of the railroad tracks is contaminated. The depth of contamination ranges from 6 in. to 18 in.

In Zone 1, the sampling data indicate that the contamination is 12 in. deep. The volume of material is 31 cu yd.

In Zone 2, the sample data indicates that the average contamination is 6 in. deep. The volume of material is 26 cu yd.

In Zone 3, the average contamination is 12 in. deep. The volume of material is 50 cu yd.

In Zone 4, the average contamination is 6 in. deep. The volume of material is 71 cu yd.

In Zone 5, the contamination is 18 in. deep. The volume of material is 6 cu yd.

Army Property 3. This area of contamination is associated with a loading dock. Cleanup of the dock will require two steps: (1) removal of dirt and debris from the dock surface as well as removal of the dock, and (2) excavation of the contaminated soils from beneath and around the dock support structure. These soils can be excavated without removing or destroying the dock support structure.

The volume of contaminated material below the dock is estimated to be 46 cu yd based on excavating the entire 825 sq ft area to a depth of 18 in. The dock volume is about 5 cu yd.

Army Property 5. Contamination extends the full length of the ditch from the raffinate pit fence line to the main ditch, a distance of approximately 800 ft. By estimate, a cross section 10 ft wide by 3 ft deep will have to be excavated to reduce the levels to below clean-up criteria. This is approximately 900 cu yd.

Army Property 6. Contamination extends approximately 650 ft downstream from the DOE fence line. Approximately 730 cu yd of material will have to be excavated along the ditch in a 10-ft-wide by 3-ft-deep swath.

Busch Property 3. The contamination in this vicinity property is limited to two small areas about 6 ft apart (72 ft^2 and 42 ft^2). It extends about 1 ft into the ground at Location A and 4 ft into the ground at Location B. This results in a total of 10 cu yd requiring removal.

Busch Property 4. This vicinity property contains three areas of contaminated soil varying from 0.5 ft to 1.5 ft in depth. The two smaller areas have approximately 11 yd^3 of contaminated soil and the large area ($6,468 \text{ ft}^2$) has 240 yd^3 for a total of 251 yd^3 of contaminated soil.

Busch Property 5. Drums have already been removed from this area. However, additional sampling indicates cleanup guidelines were not met, and contaminated soils still require removal.

Busch Lakes 34, 35 and 36. Preliminary information suggests that contamination is present in Busch Lakes 34, 35, and 36 (Ref. 112). The estimated $20,000 \text{ yd}^3$ of contaminated

sediments are assumed to be located in small areas and not to cover the entire lake bottoms. Based on this assumption, after each lake is dewatered, a backhoe could be used to excavate and load the material into trucks for delivery to the disposal facility. Cleanup of the lakes could be accomplished during the Missouri Department of Conservation (MDOC) routine clean-out of the Busch Wildlife Area lakes.

Remediation of Busch Lakes 34, 35, and 36 should be coordinated with the MDOC routine drainage and sediment removal program. After the lakes are drained, hot spots of contamination will be removed.

The Army and Busch vicinity property sites should be backfilled immediately after the contaminated material is removed, while the excavation fleet and crew is still present. Compaction to 90% of optimum density as determined by ASTM D698 (standard Proctor) may be required and can be achieved using the same equipment used to spread the backfill soil. A 90% standard Proctor compaction is considered the minimum acceptable for a controlled fill. Unless required by State regulators it is not expected that the lakes will require backfilling since natural erosion and sediment deposition will occur.

6.1.2.3.7 Water Treatment Plant Waste. As addressed in Section 5.1.2.2.8, sludge cake will be emptied from hoppers into 20 cu yd roll-off containers, and sludge brine will be pumped from tanks. Once a roll-off container is full, it will be removed, covered, loaded onto a vehicle and transported to the TSA for interim storage or directly to the waste treatment facility. The vehicle will be unloaded within the designated area of the TSA; the roll-off will store the sludge until subsequent transport to the waste treatment facility. The sludge brine will be pumped through a pipeline directly to the storage tanks at the waste treatment facility.

6.1.2.3.8 Waste from Other Areas. Removal of material from the mulch pile and Ash Pond spoils area is similar to the removal of TSA material described in Section 6.1.2.3.3. Removal of the ACM at the ACM storage area must be in accordance with asbestos regulatory requirements.

6.1.2.4 Operational Uncertainties. Modified Value Engineering Table 6.1.2-1 summarizes the preferred removal alternative for each material type and potential deviations from expected conditions. Additional details are provided in Modified Value Engineering Tables 6.1.2-2 through 6.1.2-13. These additional tables expand upon the summary table by identifying

observational method conditions and any data collection that may be required prior to design or remedial action implementation.

Recent activities have identified the presence of metallic debris and/or containers in several locations including the south dump area, the Ash Pond area, and Raffinate Pit 4. Some of this debris is completely or partially above ground, while other debris is buried around the site. Some of this rubble material includes containers (drums) of unknown contents.

Investigations are underway to locate buried rubble and debris (Ref. 113). Depending on the volume, material type, contaminant levels, and other factors, excavating of this debris and surrounding waste material may require the use of various removal equipment and techniques. Removal of surface debris can begin after the contents of any containers are analyzed.

Excavation and removal of buried rubble will also require significant safety precautions. Excavations should be performed in regulated lifts, and targeted areas should be outlined with flags or markers. Prior to excavation, the area and depth of each planned lift should be probed to determine the existence or absence of buried debris. Once all debris has been located, the last lift can be excavated with due care.

Intact containers should be placed whole in oversized containers. Ruptured containers, other debris, and proximity soils should be tested and treated accordingly. Operating equipment needed to exhumate buried materials may include specialized drum handling equipment, backhoes, and metal grappling equipment.

The capability of the Ash Pond spoils area to contain all required waste materials is uncertain. The storage area is being developed in seven phases (Ref. 114). Figure 6.1.2-14 shows the sequence for Phases I through VI. Phase VII consists of adding material on top of the materials stored in the preceding phases. Using the proposed configuration, the Ash Pond spoils area can hold about 150,000 cu yd, which is insufficient to contain all required material.

One solution is to keep adding material to Phase VII and simply build up the stockpile height. However, consideration must also be given to storm water runoff storage requirements to preclude flooding and potential uncontrolled discharge of water that has been in contact with

the contaminated materials. Hydraulic analysis has shown that storage capacity must be maintained within the Ash Pond spoils area to contain runoff.

Figure 6.1.2-15 shows an alternate configuration that provides for 270,000 cu yd of storage and 10 acre-ft of water storage. The hydraulic analysis indicated this storage capacity is sufficient to contain runoff resulting from a 25-year, 24-hour storm.

6.1.2.5 Waste Removal System Analysis. Removal equipment should be dedicated to a geographical area to prevent cross contamination, unless sufficient time is available within the schedule for equipment decontamination. Waste removal must also be evaluated from a system-wide perspective to help minimize the amount of equipment needed. The removal sequencing and scheduling described in Section 5.1.2.2.9 has been used in the waste removal system analysis presented here. The scenarios presented here are only some acceptable ones; other equipment combinations may also work. Final equipment selection, excluding dredging, will be at subcontractor discretion with the Project Management Contractor's (PMC's) approval.

As described by the sequencing and schedule, the chemical plant area building foundations, underground piping, and soils must be removed within the same time frame. A sufficient combination of backhoes, dozers, front-end loaders and scrapers will be used. Contaminated soils in Frog Pond, north dump, the raffinate pit area, and the mulch pile must also be removed concurrently with removal of the chemical plant area materials. Equipment dedicated to each area may be used if removal at all three locations occurs simultaneously, or the same equipment could be used at each successive area, if scheduling permits.

Material removal activities would continue once the treatment facility and Phase I construction of the disposal cell are complete. Critical materials requiring removal include the raffinate sludge and the MSA materials. Sludges require early removal so that the pits can be dewatered for subsequent excavation of the clay bottom material. The MSA lies within the disposal cell footprint; all MSA materials must be removed by a defined time so that cell construction is not delayed. Sludge removal will be by successive pit; clay bottom removal within each pit will begin once it is exposed.

As described in Section 6.2.7, Waste Placement, all or most of the treated sludge, concrete, rubble, and metals will be placed within the Phase I disposal cell. Consequently, these materials resident at the Ash Pond spoils area and TSA must be removed within the Phase I

waste placement time frame. Soils will be placed within Phase I for berms, roads, and filler on an as-needed basis. Material will be removed from the Ash Pond spoils area as required; the same equipment used to remove the Ash Pond spoils area concrete and rubble could be used. Depending on waste placement requirements and schedule constraints, the same removal equipment could be used at both the Ash Pond spoils area and the TSA.

Table 6.1.2-14 presents preliminary waste removal operating data. The following observations may be made when comparing these durations to the sequencing and schedules for the CSS and vitrification (VIT) treatment alternatives presented in Section 5.1.2.2.9.

- Removal of the chemical plant building area soils, foundations, and underground utilities must proceed expeditiously and in overlapping stages if there are to be no schedule delays.
- Removal of materials from Frog Pond, north dump, and the raffinate pit area must occur concurrently with removal of materials from the chemical plant building area. Relative to each other, removal can proceed sequentially.
- MSA and TSA materials must be removed concurrently.
- Ash Pond and south dump materials can be removed either concurrently or sequentially depending on when the Ash Pond spoils area material is scheduled for placement.
- Removal of the Ash Pond spoils area must proceed steadily if the CSS treatment alternative is chosen; VIT treatment offers more flexibility.
- Dewatering of Raffinate Pit 4 must begin on schedule if a potential schedule delay is to be avoided.
- Final dewatering of Raffinate Pits 3 and 4 may extend past the winter shutdown.
- Removal of vicinity property materials may be scheduled when most convenient.

- Removal of materials for CSS treatment will be a function of treatment plant throughput rates.

6.1.3 Waste Handling and Transportation

6.1.3.1 General. The waste handling and transport methods selected in Section 5.1.3 have been used to develop the waste handling and operations discussion. The equipment is compatible with the waste removal equipment selected in Section 5.1.2. The operations developed are also compatible with the waste removal operations described in Section 6.1.2. In addition, the design criteria and specifications identified in Section 5.1.3.4 and further developed during Title II design will direct the handling and transportation operations.

6.1.3.2 Handling and Transportation. Excluding the raffinate sludge, handling and transport of materials will be by a mobile fleet composed of conventional construction equipment including scrapers, front-end loaders, cranes, forklifts, backhoes, dump trucks and flatbed trucks. The raffinate sludge will be pumped through a slurry pipeline. Various levels of equipment decontamination will be required, depending on whether clean areas and public roadways are involved. At a minimum, visible gross mud and debris will require removal prior to vehicles egressing the designated removal area contaminated zone. In some cases, such as for the vicinity properties areas, temporary equipment decontamination pads must be constructed so that more extensive cleaning with hot water pressure washing can be accomplished, if necessary. The preliminary handling and transportation methods developed in *Supporting Study 15, Excavation and Water Control Plan* (Ref. 109) were used as a basis. Handling and transportation operations descriptions have been developed for the following material types:

- Contaminated soils.
- Concrete and rubble.
- Raffinate sludge.
- Other wastes: mulch, friable ACM, containers, oversized pieces.

6.1.3.2.1 Contaminated Soils. In general, contaminated soils will be removed and handled by the same equipment; in some instances the material will be stockpiled at a temporary staging area. A separate piece of equipment will then be used to transfer the material to the transport equipment. Specific operations for each area are described below.

Ash Pond Area. Provided all buried debris has been removed, scrapers are recommended for removing the soils. The scrapers would also handle and transport the materials to the disposal cell. Alternately, backhoes or dozers may be used to remove the material. In this case, backhoes or front-end loaders would transfer the material to dump trucks for subsequent transport. The latter equipment would also be used to remove soils stockpiled within the area for placement into trucks. The trucks will be traversing designated dirty roads. No decontamination other than removal of visible gross debris is expected.

Frog Pond. Handling and transport operations are identical to the Ash Pond area.

North dump. Handling and transport operations are identical to the Ash Pond area.

Raffinate pits area. Handling and transport operations are identical to the Ash Pond area.

Raffinate pit clay bottom and dikes. Backhoes and front-end loaders will be used to remove the material and place it into trucks. Trucks will travel on designated dirty roads, and no decontamination other than possible removal of visible gross debris is expected.

Soil around chemical plant area. Backhoes and front-end loaders will transfer waste to trucks. Again, travel will be over dirty roads, and decontamination will be minimal.

Vicinity properties. Stricter controls will be necessary for vicinity properties materials because they will be transported over public roadways. A specialized bulk waste haul system, similar to the quarry bulk waste removal system, may be required. At a minimum, removed material will be transferred into trucks using backhoes and front-end loaders. A tarpaulin cover would then be strapped over the waste prior to transport. Equipment decontamination procedures similar to requirements for leaving the site will be implemented. A temporary facility equipped with a water pressure washer may be required at each location. U.S. Department of Transportation, State of Missouri, and St. Charles County regulations will apply if public roadways are used. Placarding could be required. The preceding issues will be resolved during Title II design.

6.1.3.2.2 Concrete and Rubble. Concrete and rubble will be broken into 3-ft-nominal pieces. Cutting and breaking will be by backhoes equipped with appropriate attachments including shears, pulverizers, and saws. Following breaking and cutting, material

will be placed into trucks using grapples or front-end loaders. In some instances, it may be desirable to transport oversized pieces that will not fit within the dump truck. In these instances, pieces would be placed on a flatbed using a crane and then securely tied down. Transport will be over designated dirty roads. Section 6.3.4 also discusses handling and transport of concrete and rubble.

6.1.3.2.3 Raffinate Sludge. The dredged raffinate sludge will be pumped through a slurry pipeline to the dewatering facility. Figure 6.1.3-1 shows the interrelationships among dredging, pumping, dewatering, and water return operations. Water management is important to ensure that enough water is available to slurry the material once removed. No equipment decontamination is necessary; piping will be placed into the cell once sludge removal is complete.

6.1.3.2.4 Other Wastes. Other wastes requiring transport include mulch, ACM storage area materials, metals, and containerized waste. Transport will be over designated dirty roads.

Mulch. Transfer to dump trucks using front-end loaders.

ACM. Asbestos regulations in 40 CFR 61 Subpart M must be followed when handling and transporting these materials.

Metals. Depending on size, TSA and MSA metals will be handled by grapples, front-end loaders, and cranes and then transferred to either dump or flat-bed trucks.

Containerized waste. Depending on sizes, containers will be handled using forklifts or cranes and then transferred to flat-bed trucks. It is presumed that containers with waste not requiring treatment will be placed within the disposal cell.

6.1.3.3 Decontamination. Equipment decontamination requirements are straightforward; established project procedures will apply. For equipment traveling routinely over designated dirty roads, visible gross mud and debris will be removed and the vehicle will be scanned. Provided levels are not exceeded, the vehicle can then proceed. If these levels are exceeded, the vehicle will then proceed to the nearest decontamination pad.

Equipment that will be traveling within a dirty area will proceed to the nearest decontamination pad for clearance prior to entering the clean area.

Equipment exiting a vicinity property work zone will be required to follow procedures similar to the site procedures for site egress.

6.1.3.4 Operational Uncertainties. Operational uncertainties associated with waste removal and handling are similar to uncertainties affiliated with material removal. Scraper efficacy is dependent upon the level of contaminant spread that can be tolerated. Trucks can contain the material more efficiently than scrapers. Haul road traffic is a concern and work should be scheduled to minimize traffic congestion. Road grades, especially on the disposal cell dike slopes, will affect equipment selection. As discussed in Section 6.1.5, Site Roads, grades must not exceed transport equipment capabilities. The ability to transport the sludge by slurry pipeline must also be verified. As with the dredge, a pilot test is needed to confirm treatability.

6.1.3.5 Handling and Transportation Systems Analysis. Table 6.1.3-1 presents preliminary waste transportation operating data. The haul cycle times have been calculated using a fixed time of 4.7 minutes to load and dump a truck. Travel time has been calculated using haul route length and an average speed of 15 mi/hour. Efficiency is 50%. Using the waste removal operating data developed in Section 6.1.2 and the sequencing and schedules developed in Section 5.1.2.2.9, the following observations may be made:

- Truck traffic will be heavy during removal activities at the chemical plant, north dump, Frog Pond, and the raffinate pit area.
- Truck traffic will be heavy during MSA, TSA, and raffinate pits material removal during CSS treatment.
- Excluding Phase I, truck traffic will be reduced if the VIT alternative is selected because of the longer Phase I schedule. Removal requirements are identical if delays are to be avoided.

6.1.4 Construction Materials Staging Area

6.1.4.1 General. The preferred construction materials staging area (CMSA) location is described in Section 6.1.4.2. Site preparation activities, surfacing materials placement, and surface drainage control procedures for the CMSA are described in Section 6.1.4.3, 6.1.4.4, and 6.1.4.5 respectively. Uncertainties that could significantly affect the construction and operation of the CMSA are listed in Section 6.1.4.6. Finally, Section 6.1.4.7 presents an overall CMSA system operation analysis for the preferred designs discussed in Sections 6.1.4.2 through 6.1.4.5.

6.1.4.2 Location Siting. Section 5.1.4.2 identifies the preferred location for the CMSA as the area north of Ash Pond. Figure 5.1.4-4 shows the conceptual CMSA site layout. The area borders the north and west chemical plant boundaries. Ash Pond and the MSA border the south. The east side will be the access point to the CMSA from off site and from the CMSA to the disposal facility. Delivery trucks bringing new construction materials from off-site sources will enter the north access point located on the east side of the CMSA (Figure 6.1.4-1). After entering the site, trucks will remain in designated clean areas while delivering loads. A loop roadway system within the CMSA will allow the trucks to exit through the same easterly access point without encountering any contamination. Once the required reserve storage amounts have been stockpiled in the CMSA, the trucks will be able to deliver loads directly to the disposal cell. The trucks will stay on clean roads throughout the looped route.

6.1.4.3 Site Preparation. Section 5.1.4.4 describes the types and sequence of site preparation activities for the preferred location. Erosion protection around the perimeter of the CMSA will be provided to control sediment migration. Two detention basins will be built inside the north portion of the CMSA boundary. Diversion ditches along the CMSA perimeter will direct water into these basins. Due to the existing contaminated soils within the CMSA, straw bales will be placed around the contaminated soils to prevent surface run-on to these areas. In addition, to control contaminated runoff, a small detention basin will be built within the contaminated area and a pump-truck periodically will pump out any potentially contaminated accumulated water. Once these erosion protection measures are in place, most of the uncontaminated area will be cleared and grubbed. After clearing and grubbing are completed, contaminated soil can be removed. A temporary haul road will be built between the CMSA and Ash Pond. The contaminated soil can then be excavated and delivered to the Ash Pond spoils area for temporary storage (Section 5.1.2) until it is placed in the disposal facility.

6.1.4.4 Surfacing. As described in Section 5.1.4.4, the preferred surface for the synthetic and natural materials storage yard and internal CMSA roadway network is gravel, and dirt is the preferred surface for the clay borrow storage and staging area. The gravel portion of the CMSA will require excavation or scarification and recompaction of subgrade material to a minimum compacted thickness of 6 in. A minimum of 8 in. of compacted surface and 22 in. of compacted aggregate base are required. Figures 5.1.5-19 and 5.1.5-20 illustrate the gravel surface and base course section for different types of vehicle loading.

The surface and base course gravel shall be compacted to 95% relative compaction as determined by ASTM D1557 test method (modified Proctor), with a maximum compacted lift thickness of 6 in. The degree of compaction was chosen to provide adequate support for the design vehicle load with the 8-in. surface thickness. To achieve the required degree of compaction, the gravel shall be compacted by a vibratory smooth-drum roller. Final rolling may be accomplished either by a vibratory roller using only static force or by means of a pneumatic tire roller. Requirements for vibratory and pneumatic tire rollers will be specified in the subcontract.

To control dust, a water truck will periodically spray the area. A perimeter clean route around the site, as discussed in Section 5.1.4, would be included in the CMSA design to provide for a traveled route through the CMSA.

6.1.4.5 Surface Drainage Control. Two sedimentation basins will be installed along the northern portion of the CMSA boundary. Runoff from the site will be directed to these sedimentation basins. Runoff from the southwesterly portion of the CMSA will discharge to the Ash Pond diversion ditch. A sketch of the drainage system is shown in Figure 6.1.4-2. Diversion ditches will be excavated around the perimeter of the CMSA to contain sediment and to control runoff. Straw bales will be tied with wire and used to filter sediment in drainageways and to divert overland or sheet flow. As indicated in Section 5.1.4.5, additional erosion control measures such as hydroseeding and matting may be used, if necessary. The eastern area of the CMSA that contains the synthetic and natural materials storage yard will have a gravel surface and will need minimal erosion control measures. The runoff will be diverted directly into the detention basin. The on-site clay stockpile will require greater erosion control measures. With 2:1 sideslopes, erosion will occur as the stockpile builds. As indicated in Section 5.1.4.5, temporary erosion protection including straw bales, hydroseeding, silt fences, and matting can be used to prevent sediment transport. Any one or a combination of two or more of these

devices can be applied to control erosion. Specifically, the erosion protection measures for the on-site clay stockpile will be placed at the top and toe of the slope. Runoff over the side slopes will be diverted to selected spots around the perimeter of the stockpile and then allowed to run down a riprap-faced slope. Silt fences or straw bales will be placed at the bottom of the slope around the perimeter of the toe to block sediment migration.

6.1.4.6 Operational Uncertainties. The major operational uncertainties for the CMSA are summarized below.

- The amount of uncontaminated clay borrow to be stored at the CMSA is unknown and will remain unknown until waste excavation and removal in the disposal cell footprint is completed. If on-site borrow storage requirements are excessive, the natural and synthetic materials must be stored at an alternative location. If most of the clean material can be excavated from the disposal cell footprint and placed directly in the clean-fill dikes (CFD), the size of the CMSA can be reduced.
- The size and boundaries of an on-site CMSA would be fixed due to the limited space available for construction activities. With the great contingency in storage quantity estimates, it is not certain if the preferred on-site CMSA location can meet all of the storage requirements. While the probability of not meeting storage requirements is low, it could have an adverse affect on disposal cell construction.
- Access to the site, and particularly access to the CMSA, must be restricted to prevent the spread of contamination. Vehicle scanning and decontamination requirements may affect CMSA operations. It is currently assumed that clean vehicles may enter and exit the CMSA without being scanned or decontaminated.
- The extent and volume of contamination in the preferred on-site CMSA location is unknown. If site preparation of the CMSA is delayed, it will affect many other site activities.
- Site preparation of the CMSA involves the transportation of contaminated material to the Ash Pond spoils area. It is uncertain whether the Ash Pond spoils area can contain all of the contaminated material without spilling over into the designated clean CMSA.

- A gravel surface will provide adequate support for the CMSA internal roadways and synthetic and natural materials yard, with some tolerable rutting. However, rutting in gravel roads may exceed tolerances on roads with very heavy traffic, and an asphalt surface and/or geotextile surface may be required for these roads.
- If synthetic and natural materials are to be stored off site (off-site CMSA), land ownership and permitting problems may arise.

6.1.4.7 CMSA Operation System Analysis. The CMSA must be completed before construction of the disposal facility begins. According to the current disposal cell construction schedule, the below-grade clean clay borrow excavation begins approximately 1 month before Phase I of the CFD construction begins. At this time, it will be determined whether the below-grade clay borrow will be stockpiled or placed directly into the CFD construction. If the option is to place the below grade clay directly into CFD construction, then only the east side of the CMSA must be built (synthetic and natural material staging area). The west side (on-site clay borrow storage) is eliminated. If the option to stockpile the clay borrow is chosen, then the entire CMSA must be built. Whichever option is chosen, the construction of the eastern portion of the CMSA must begin immediately, so that it will be ready for the disposal facility Phase I construction, which is scheduled to begin eight months later.

Another aspect affecting the size of the CMSA is the unknown amount of contaminated soil storage that is required and whether contaminated soil can be temporarily stored in the Ash Pond spoils area. If additional storage capacity for contaminated soil is needed, the area north of Ash Pond is the only viable location for temporary storage. This may require relocating the synthetic and natural material storage area off site and relocating the on-site clay borrow storage area (providing the worst case scenario) in the eastern portion of the CMSA. The contaminated material would be limited to the southwestern portion where the drainage naturally runs to the Ash Pond diversion ditch. However, this option requires additional study of the MDOC-South to develop a complete staging yard for the synthetic and natural material.

6.1.5 Site Roads

6.1.5.1 General. The remediation of the chemical plant site will require the transportation of waste and new construction materials from various locations on site. Waste materials will be transported to new locations for treatment, stockpiling or staging, and disposal.

Construction materials will be transported from off-site borrow areas, to and from on-site staging areas, and to new construction areas. The function of an on-site road system is to provide a well-organized network for efficient transport of construction materials and waste.

One of the performance requirements of the site roads is to prevent cross-contamination of clean and dirty roads. To accomplish this, on-site roads will include the following categories:

- Clean roads for vehicles entering the site to deliver material to the CMSA.
- Clean roads for vehicles that must travel throughout the site to various uncontaminated locations.
- Dirty roads dedicated to hauling waste material.

Access to the site from existing public roads will be provided by four access locations:

- (1) Employee/contractor/subcontractor access for personnel at the existing main entrance from Missouri State Route 94
- (2) Haul road from quarry (existing south entrance)
- (3) SWTP access (existing access from Route A)
- (4) Construction material hauling entrance from an existing abandoned roadbed which leads to Missouri State Route 94 (new north access).

The four off-site access locations will direct all project related traffic to Missouri State Route 94, thereby mitigating concerns over the use of County Route D (Ref. 43). The use of four access locations also allows for the separation of heavy construction equipment and employee vehicles by access location.

The operational factors evaluated in the design of the site roads system were:

- **Speed limit.** The posted speed limit at the site is 20 mph. This was considered to be a reasonable speed limit on the relatively flat site where visibility on site roads will be good in most areas.
- **Load limits.** Vehicles with a range of weights from 3 tons to 90 tons gross vehicle weight can be expected to travel on-site roads. To accommodate most of heavy construction vehicles on site roads, a 50-ton dual axle load was used in the design of the typical roadway section for on-site roads.
- **Traffic directions.** Site roads will be either one-way single-lane or two-way double-lane roads. Where two-way traffic volumes are low, a two-lane road may be reduced to a one-lane road with turnouts to accommodate two-way traffic. It will be necessary to estimate traffic volumes on site roads, so that an appropriate number of lanes can be assigned to each road.
- **Truck size.** Lane widths were designed to accommodate the largest expected vehicle width of 16 ft.
- **California Bearing Ratio (CBR) values.** In situ subgrade soil was assumed to have a CBR=3. Compacted subgrade material (subbase) was assumed to have CBR=7. The CBR values of asphalt concrete, Portland cement concrete, and oil and rock surface are high enough to support any load, and compacted gravel was assumed to have CBR=30 (base or surface course).

Where applicable, the Missouri Standard Specifications for Highway Construction (Ref. 44), the Missouri Standard Plans for Highway Construction (Ref. 45), and the St. Louis County Standard Specifications for Highway Construction (Ref. 46) were incorporated into the conceptual design of site roads.

6.1.5.2 Traffic Pattern. Figures 5.1.5-3 through 5.1.5-8 illustrate the expected traffic patterns on site roads from the start of disposal cell construction through the closure phase for the CSS alternative. The figures show the use of designated clean and dirty roads, as described in Section 6.1.5.1 and in Sections 5.1.5.2.1, 5.1.5.2.2, and 5.1.5.2.3. Figure 5.1.5.-9 shows the traffic pattern at closure phase for the VIT alternative.

Roads within the disposal facility area and ramps leading from site roads to the disposal cell will be designed as a part of the disposal facility (Section 5.3). Vehicles transporting clean material to the cell will enter and exit the disposal cell area via clean ramps which lead to a clean site road. All other vehicles entering the disposal cell area must enter and exit the cell on dirty ramps and travel only on designated dirty site roads.

Actual traffic patterns will depend on daily sequencing and scheduling of cleanup activities and will also accommodate site cleanup and closure activities. Site roads provided are adequate for the contractor to operate an efficient cleanup. Radio dispatching may be used to enhance traffic flow, especially from the treatment facility to the disposal facility where timely delivery of the treated product could be critical.

6.1.5.3 Roadbed Preparation. All contamination will be removed during the preparation of roadbeds for all new roads, whether designated clean or dirty.

Figures 5.1.5-19 and 5.1.5-20 illustrate the typical roadbed for one-way single-lane and two-way double-lane site roads, respectively. The road section requires the excavation or scarification and recompaction of subgrade material to a minimum compacted thickness of 6 in. Roads for highway vehicle traffic will require 16 in. to 18 in. of aggregate base, and off-highway vehicles will require 22 in. to 26 in. of aggregate base, depending upon the type of surface material (see Figures 5.1.5-19 and 5.1.5-20). Since the construction of the roadway section will require the compaction of both cohesive and cohesionless material, it may be necessary to use different types of compaction equipment, such as vibratory and pneumatic tire rollers.

6.1.5.4 Surfacing. A performance requirement of the site roads is to provide a surface course to minimize dust and rutting and to support the design vehicle loading. Since site activities require an efficient network of site roads, both the construction and performance of site roads will significantly impact cell construction and other site operations. Section 5.1.5.4 discusses how different surfaces of the site roads impact operations.

A gravel surface was chosen for good dust control, good performance, ease of construction, and relatively low maintenance requirements. In addition, the use of gravel does not add to the volume of contaminated material. Figure 5.1.5-19 and 5.1.5-20 illustrate the gravel surface and base course for typical roadway sections. The gravel in both the base and

surface courses shall be compacted to 95% modified Proctor. The degree of compaction was chosen to provide adequate support for the design vehicle load. To achieve the required degree of compaction, the gravel shall be compacted with a vibratory roller not less than four complete coverages with a maximum compacted lift thickness of 6 in. Final rolling may be accomplished either by a vibratory roller using only static force or by means of a pneumatic tire roller. Requirements for vibratory and pneumatic tire rollers will be specified in the contract (Table 5.1.5-2). The specified degree of compaction ensures a surface with durability, and strength.

6.1.5.5 Operation and Maintenance. The gravel surface will require maintenance to repair ruts and other surface deformations caused by traffic. Motor graders will be used as needed to repair ruts and smooth road surfaces. Water trucks will travel the site roads continuously to control dust. As described in Section 5.1.5.2, Site Roadway System, a clean water truck will spray water on clean roads and a dirty water truck will spray dirty roads. Compaction equipment and other equipment used for disposal cell construction should not be used to repair site roads, as this may impact cell construction. Therefore, separate maintenance equipment should be retained on site to repair site roads.

6.1.5.6 Site Roads Operational Uncertainties. After preferred alternatives were selected for site roads design criteria, the observational method was applied to identify uncertainties in the site roads system plan. The following uncertainties remain:

- (1) The site roads design assumes that vehicles transporting clean materials to the site may enter and exit the site on clean roads without passing through a decontamination facility. It is uncertain whether all clean vehicles will be allowed to exit the site without being scanned. If clean vehicles must be scanned before exiting the site, a decontamination pad must be constructed near the north access for vehicles traveling between the CMSA and the off-site borrow area. These vehicles must remain on clean roads while they travel within the site boundary to prevent contamination of the CMSA.
- (2) The uncertainty regarding whether or not waste placement or other site work will be performed at night affects the site road design. Lighting systems must be installed, and visibility along sight roads must be examined more carefully if work is to be performed at night.

6.1.5.7 Specifications. Each site road design criterion and specification was evaluated using an MVE approach. Alternatives were generated to meet the operational requirements listed in Section 6.1.5.1 and the functional and a performance requirements of each design criterion or specification. The alternatives were then evaluated using weighted criteria ranked in order of importance, and preferred alternatives were selected. Following is a list of guidelines for site roads design criteria and specifications (as developed in Section 5.1.5.2-6):

- (1) **Horizontal curves.** The minimum inside radius of horizontal curves is 100 ft. Where construction activity limits the length of horizontal curves, a lower radius is permitted, if a means of reducing vehicle speed is provided before the curves.
- (2) **Roadbed width.** One-way single-lane roads for highway vehicles will be 12 ft wide with 0-ft to 2-ft shoulders. Two-way double-lane roads for highway vehicles will be 24 ft wide with 0-ft to 4-ft shoulders. One-way single-lane roads for off-highway vehicles will be 16 ft wide with 0-ft to 3-ft shoulders; two-way double-lane roads for off-highway vehicles will be 32 ft wide with 0-ft to 4-ft shoulders. Where two-way traffic volumes are low, a double-lane road may be reduced to a single-lane road with turnouts to accommodate two-way traffic.
- (3) **Maximum grade and vertical curves.** The maximum grade on site roads is 6%. Grades up to 10% will be permitted for short distances, such as on ramps. A vertical curve is required if the tangent-grade change exceeds 5% or where the grade change exceeds 1% in areas where better visibility along site roads is needed.
- (4) **Roadway cross slopes.** Roadbeds will have a crown slope of minimum 2% to maximum 6%. Where drainage specifications require runoff to drain to one side of the road, roadbeds will have a 2% to 6% cross slope.
- (5) **Side slopes.** Site roads will have side slopes of maximum 3H:1V. Where construction activity limits the width of side slopes, maximum 2:1 slopes will be permitted.
- (6) **Surface material.** Gravel surfaces will be compacted to 95% standard Proctor.

6.1.5.8 Site Roads System Analysis. The design of the site road system was oriented toward providing safe, efficient travel during each phase of construction by developing the layout in five sequences, illustrated in Figures 5.1.5-3 through 5.1.5-8. The site roads design criteria also include alternatives for special conditions, such as spatial constraints or hazardous conditions along site roads. In general, the emphasis of the site roads design was to meet the needs of various site activities during remediation.

6.1.6 Site Drainage

6.1.6.1 General. Chemical plant remediation, disposal facility construction, and site closure will require storm water drainage systems to prevent the occurrence of standing water and to maintain dry working conditions. The site drainage system will also function as a containment system to prevent the release of contaminated runoff from the site during remediation and waste placement activities. Ditches and retention and detention facilities will need to be constructed. Once constructed, the temporary facilities will require regular maintenance to ensure proper operation. Temporary drainage facilities should be in place before initiating any cleanup or construction activities.

Figure 6.1.6-1 illustrates the construction sequence for sedimentation basins and retention ponds. To prevent the release of sediments into off-site drainages, sediment detention basins must be in place prior to initiating chemical plant remediation. Drainage channels needed for site haul roads should be constructed concurrently with the haul roads. Conveyance systems for transporting runoff from uncovered waste in the cell should be constructed before waste placement begins for each phase. All drainage structures will be constructed to approved specifications, and any operational requirements for drainage structures will be included in the final design procedure.

6.1.6.2 Operation and Maintenance. Figure 6.1.6-2 shows the construction schedule for site drainage control structures. Figures 5.1.6-3 through 5.1.6-7 show anticipated drainage patterns for the disposal facility construction phases. These figures show the locations of major drainage channels, pipes, and culverts needed to accommodate the anticipated drainage patterns.

Temporary drainage channels can be constructed using standard earth-moving equipment such as bulldozers, plow-type ditching implements, and backhoes. Riprap placed in channels should maintain the channel shape to ensure the channel operates as designed.

Filter fabric should be placed beneath riprap in temporary channels. Channels should be maintained by removing weeds, stabilizing and repairing areas of degradation, and removing deposited sediment using hand tools if accumulations are excessive.

Excavation prior to construction of retention ponds and detention basins can be accomplished using hydraulic backhoes, scrapers, front-end loaders, and bulldozers. Clay liners should be compacted using sheepsfoot rollers or hand-held tampers. During construction of sedimentation basins and retention ponds, the existing channel should be diverted around the construction area. Suitable soil erosion control measures, such as straw bale dikes and mulching, should be used to protect disturbed soil areas during construction. Hydro-seeding or erosion blankets should be used to cover disturbed areas immediately after construction is completed.

Permanent drainage channels and grade control structures should be constructed concurrently with final site grading operations. The locations of permanent drainage channels are shown on Figure 5.1.6-12. Bulldozers and backhoes can be used to construct channels and grade control structures. Dumped riprap should be used if channels require stabilization. Riprap should be underlain by a granular filter layer. Straw bale dikes or silt fencing should be placed along channel banks to minimize sediment deposition within channels until permanent vegetation is established.

Facilities will be required within the CMSA for stockpiling construction materials for the site drainage system. These materials include riprap, filter fabric, granular filters, clay lining, culverts, piping for sediment basin outlet works, and geotextiles for lining retention ponds.

6.1.6.3 Operational Uncertainties. The site drainage system will be designed to operate for the design storms listed under design criteria in Section 5.1.6.6:

- 25-year, six-hour storm for temporary drainage channels.
- 100-year, 24-hour storm for permanent drainage channels.
- Volume from 25-year, 24-hour storm for retention ponds.

- 25-year, six-hour storm for culverts.

A 100-year, 24-hour storm was used for permanent channel design rather than the probable maximum precipitation (PMP) storm since existing channels in the vicinity of the site are probably not capable of conveying a PMP storm without degradation. Designing permanent channels for the PMP is not considered practical. Also, if a riprap apron is included in the disposal cell design, the apron will be designed to maintain stability during a PMP event and to deter headward erosion that may occur in permanent drainage channels.

If designed properly, the necessary hydraulic performance of the drainage structures can be achieved for the design storms listed. If design storms are exceeded, freeboard specified for drainage channels will provide a factor of safety against channel overtopping. Freeboard and emergency spillways designed for sedimentation basins and retention ponds will provide factors of safety against overtopping and possible damage to these structures if design conditions are exceeded. The possibility of a storm event exceeding the design conditions appears remote for the operation or pre-site closure period. Weather records for St. Charles, Missouri, for the period from 1951 through 1980 (National Oceanic and Atmospheric Administration (NOAA) undated) indicate that the greatest daily rainfall amount was 4.50 in., slightly less than a 25 year, 6-hour storm of 4.52 in.

Permanent drainage channels should be designed so that maintenance is not necessary. These channels designs should consider the presence of weeds that will intrude in channels after site closure. A rock apron encircling the disposal facility would inhibit gully or headward erosion that may occur in permanent drainage channels located at the toe of the disposal facility. Locations where headward erosion may occur are shown in Figure 5.1.6-12.

Proper maintenance will be required to ensure efficient operation of the site drainage system. During the operational period, drainage channels and culverts should be cleared of debris and weeds on an as-needed basis. After major storm events, drainage channels and sediment control structures should be inspected for damage and repaired, if necessary.

Sedimentation basins and retention ponds periodically will require sediment cleanout to maintain adequate capacity. Capacity for sediment accumulation will be provided for sedimentation basins and retention ponds. Annual inspections should be performed to determine if removal of accumulated sediments is required.

6.1.6.4 Outline of Specifications. The following specification outline details construction and operation requirements that need to be addressed in the design criteria and specifications listed in Section 5.1.5.6.

- **Sedimentation Basins and Retention Ponds**
 - Placement and compaction of clay liners.
 - Placement of geosynthetic liners.
 - Placement of riprap and filters.
 - Construction of the outlet works.
 - Sediment capacity.
 - Operation of outlet works.
- **Temporary ditches**
 - Placement of riprap and filter fabric.
 - Tolerances for channel cross section dimensions and grade.
 - Installation of culverts.
 - Removal of debris.
 - Mowing requirements.
- **Permanent channels (post-closure)**
 - Placement of riprap and granular filters.
 - Construction of grade control structures.

Specifications will also be required for pump sizes and the pumper trucks (if required) to transfer contaminated water from retention ponds and temporary sumps to the designated treatment facilities.

Design criteria and specifications should include cleanup and release criteria for retention pond liners, sediments removed from sedimentation basins and ditches, and pumps and piping used for transporting contaminated water.

6.1.6.5 Site Drainage System Analysis. Drainage system operation and performance may be interrupted or altered by other activities. A conflict may exist between placing waste in the Ash Pond spoils pile and maintaining sufficient capacity within the pond to contain the design storm. During periods of heavy rain, maintaining the design capacity by removing stockpiled soil will be necessary to ensure that storm water within Ash Pond does not overflow the structure. During the drier winter periods (October through March), it may be permissible to relax storm water capacity to provide additional storage capacity.

A conflict within the drainage system design itself is the mixing of contaminated and noncontaminated runoff in the Ash Pond isolation dike (Retention Pond 3). Clean runoff will originate from the exterior of the CFD and Raffinate Pits 1 and 2 and portions of Pit 3, as illustrated on Figure 5.1.6-7. Based on the current design, the mixing of contaminated and noncontaminated runoff is unavoidable.

Construction of the CFD for the disposal facility will result in the filling of the Ash Pond isolation dike if side slopes are maintained at 5:1 (H:V). The dike should remain functional at full capacity until site closure. Temporarily constructing the CFD side slopes at 2:1 (H:V) will enable the dike to be used for the duration of disposal facility construction and site remediation (Sections 5.2.7.3 and 6.2.6.2).

6.1.7 Borrow Operations

6.1.7.1 General. Different types of borrow materials required are discussed in Section 5.1.7. Discussion includes:

- Locations and functions of the different types of borrow material.
- Performance requirements for borrow materials.
- Required volumes of each material type, as required by the present design.
- Design characteristics of the different types of borrow material.
- Field testing and required properties for the field tests.
- Preferred borrow sources.

This section discusses operations needed to obtain borrow materials. Borrow operations include:

- Production of materials (e.g., excavation, crushing, and screening) at the preferred borrow source.
- Sample selection and field testing of the borrow material produced at the borrow source to ensure that it meets requirements.
- Storage at the source.
- Transportation to the site.
- Stockpiling/storage at the CMSA.
- Placement of the material at its final location, including moisture conditioning and compaction, as required.

This section also addresses the uncertainties associated with the borrow operations, such as the impact of weather or delivery complications. A list of specifications, associated with the functional aspects of borrow operations, is also included in this section. Finally, a systems analysis is performed to address the issues involved with the integration of the borrow operation into the overall construction/remediation activities at the site.

6.1.7.2 Production of Borrow Materials

6.1.7.2.1 Borrow Material Production at the Weldon Spring Conservation (Wildlife) Area. The borrow area within the Weldon Spring Conservation (Wildlife) Area (WSCA) shown in Figure 5.1.7-3, is the preferred source for:

- General fill (particularly for the CFD)
- Low-permeability material
- Rooting medium Layer 2

This source will supply from 1.0 million cy^3 to 1.6 million cy^3 of material. Efficient operations will require thorough, comprehensive planning. As indicated in Section 5.1.7.4.3, a comprehensive engineering study is under way to address the borrow operations in this area. Based on geologic, geotechnical, hydrologic, and geomorphologic studies, a borrow operation

plan will be developed. The plan will recommend the area to be enclosed, an excavation plan, plans for erosion control during construction, site restoration plans, stockpile locations, and temporary road alignments. These plans will be used to develop the final borrow operations construction documents for final design (Title II).

Preliminary assessments indicate that a sufficient volume of appropriate material (including adequate contingency) may be obtained from the approximately 204-acre area shown on Figure 6.1.7-1, with excavation depths ranging from 10 ft to 25 ft. The area includes sufficient area for stockpiling excavated materials, temporary roads, and staging and processing areas.

The Project Management Contractor's (PMCs) designated representative will direct all construction activities at the WSCA borrow area. Prior to initiating borrow operations, a fence will be posted around the designated area, and restricted access warning signs will be installed at appropriate locations. A gate will be placed at the site entrance to control access by pedestrian and vehicular traffic. The site will be cleared of all vegetation and temporary roads will be constructed. Areas for stockpiles, material staging and material processing will be laid out. Sediment control structures will be constructed inside and outside the construction area to prevent silts from encroaching into surface waters and groundwaters of the state. A storm water permit must be issued by the State of Missouri before earthwork activities begin. This should be incorporated in the construction schedule. A conceptual plan for development and operations at the WSCA borrow source is presented on Figure 6.1.7-1.

After site preparation is completed, excavation of borrow materials will proceed in accordance with the excavation plans developed. Excavation operations will be designed as a phased operation to minimize the area disturbed and the excavation will be backfilled and restored expeditiously. Reclamation is discussed in detail in Section 6.1.7.7. First, a 6-in. layer of topsoil will be removed from the area designated for excavation, and stockpiled in its designated area for later use in site reclamation. The excavation will then be advanced deeper into the topsoil, and the excavated material will be stockpiled at its designated area for later use as rooting medium Layer 2. This second-stage excavation is expected to extend to 2 ft below the surface. The general fill (primarily for CFD) and the low-permeability material will be removed from beneath this zone.

It is not presently certain whether all or part of the general fill material that is excavated will also suffice as low-permeability material for use in the basal liner, infiltration barrier, or the radon barrier. The results of *Supporting Studies 5A and 8A*, and the planned geotechnical investigations for the study under way for this borrow source will help resolve this issue. In any case, depending on the material's designation, the material will either be hauled to the site, stockpiled at the borrow source (awaiting further processing or transport), or further processed (pulverized or wetted/dried).

The PMC's designated representative will supervise all borrow operations. The representative will determine the classification/suitability of a material, whether further processing is required, and whether the material should be stockpiled or loaded on off-highway vehicles for transport to the site. All operations should strictly follow OSHA guidelines and the Health and Safety Plan (HASP) prepared for this project. Excavation slopes shall not exceed 1:1 and shall be protected from cave-ins. Personnel should be protected from falling into the excavation by barricades, designs, etc. The site should be fully lighted if work hours extend beyond dusk.

Water with additives should be used, as required, to eliminate visible dust. Water should be applied from water trucks with a spray system or hoses with nozzles that will ensure an economical use of water. All equipment used to apply water should be equipped with a positive means of shut-off. Water should be available for use at the site at all times. Additives may be used to conserve water; the type and concentration of the additives should be approved by the PMC and the MDNR, prior to being used. In addition, the type and concentration of the additive should be noted in the storm water permit.

Water may also be required for moisture conditioning of the borrow soils, if the soils contain less than the specified moisture. The water for moisture conditioning should be applied by pipelines equipped with a spray system or hoses and nozzles that will ensure uniform application. All equipment used to apply water should be equipped with a positive shut-off. Additives will not be used during moisture conditioning.

Other borrow operation activities running concurrently with the borrow production activities, include sample selection and the performance, transportation, storage of borrow materials, placement and site reclamation of borrow source. These activities are in the following sections.

6.1.7.2.2 Borrow Material Production from the Commercial Sources. Production operations for commercial sources of materials such as rock, sands and gravels, loam, and gravelly topsoil will also be overseen by the PMC's designated representative, who will coordinate sample selection, testing, transportation, and any required stockpiling with the appropriate facility personnel. Management personnel from the commercial source will coordinate material production plans with construction plans, in consultation with the PMC's representative.

6.1.7.3 Sample Selection and Test Performance. Field testing of the borrow materials will be performed concurrently with the borrow material production to ensure that the borrow materials satisfy their intended functions. The field tests required are discussed earlier in Section 5.1.7.2 and are presented in Table 5.1.7-1. The table also lists proposed testing frequencies and the properties required to satisfy the material requirements.

The PMC's representative will select representative samples from the processed (e.g., excavated, crushed, screened) material for testing at predetermined frequencies. If the test results indicate that the material does not meet the required characteristics, three additional representative samples of the material in question will be collected and retested for all required tests. During testing, production of the material will be stopped, or any material that is produced after the failed test will be clearly identified. In the event that all three samples pass the retests, the initial "failed" test will be ignored and the process will be allowed to continue. In the event that at least one of the three samples fails the retests, all material produced since the initial failure will be rejected. In addition, any material that was already transported to the site and that does not meet the specifications will be identified, removed, and wasted.

The process of identification and subsequent rejection of any material presents a sensitive and complex situation, and therefore, extreme care should be exercised to minimize the potential for rejection. An experienced engineer/geologist present during the operations may easily identify questionable material by visual inspection and rudimentary testing, thereby greatly minimizing the potential for failed tests. Also, if stockpiles are adequately controlled to document how much and when a specific volume was placed, the material under question can easily be identified. In particular, every effort should be made to avoid the need for removal of material after it has been transported to the site.

6.1.7.4 Transportation. The borrow materials produced off site will have to be transported to their final locations. The method of transportation and the schedule should be suitable and cost-effective (e.g., available or constructed haul roads for truck traffic), be able to meet the construction schedule and consequent demands on the borrow material, ensure available storage space at the borrow location and at the CMSA, and implement appropriate dust control measures.

The area within the WSCA shown in Figure 5.1.7-3, located about one mile east of the site has been designated as the most significant borrow area in this study. It is the source of material for site reclamation; CFD; low-permeability material for radon barrier, infiltration barrier, and bottom liner; and rooting medium, Layer 2. Approximately 1.6 million cu yd of material will be moved from this area. Transportation of the material from this area was studied and it was decided that borrow materials will be transported by off-highway vehicles, using a gravel haul road to be constructed for this purpose. The haul road will cross under Missouri State Route 94. A detailed discussion on this issue is presented in Section 5.1.5 (Site Roads).

The delivery of all the other borrow materials will most likely be by standard highway trucks using existing highways. These materials include rock, sandy soils for filters, drains and bedding materials, base and subbase soils, and gravelly topsoil and rooting medium Layer 1 for the vegetated cover top slope. As indicated earlier, only commercial sources are being considered for the rock and sand in *Supporting Study 5C* (in progress) (Ref. 52). Noncommercial sources will be investigated in the event a viable commercial source is not available or is prohibitively expensive. The transportation issues (haul distance, presence of highways, access to the source) are important criteria for choosing a particular source.

Dust emissions, particularly from fine grained borrow materials, will require proper control. Covers must be placed on top of the material during transportation.

6.1.7.5 Storage of Borrow Materials. The CMSA shown on Figure 5.1.4-4 and discussed in Section 5.1.4 is designed primarily to store membrane liners, geotextiles, and pipes. It is also expected to serve as a storage area for the borrow materials for a maximum of three weeks, if there are production or delivery difficulties. Therefore, primary storage requirements will generally have to be fulfilled at the off-site borrow source itself.

Based on the construction schedule presented in the *Cost and Schedule Document* (CSD), it is evident that a continuous supply of material should be scheduled from the WSCA except for the winter shutdowns. The proposed area to be excavated is extremely large. Therefore, the excavation plans should be designed so that there is room for storage of the material at all times.

The primary storage areas required at this borrow source are:

- Storage of the topsoil for later use in the vegetated cover as rooting medium Layer 2. All of this topsoil must be stored, since it covers the other soil, but will not be used until later in the project.
- Initial indications are that the in situ soils designated for general fill and also for low-permeability material often appear to be somewhat wet (e.g., 5% wet of optimum moisture content). Therefore, these soils need to be dried before placement at their final location. This will have to be done in the stockpile/storage area.
- Storage of soils may be required if, from the construction standpoint, excavation is being achieved at a faster rate than transportation and delivery. Facility for storage allows greater flexibility for the total operation.

A conceptual storage plan is presented in Figure 6.1.7-1. The storage area plan will be modified as appropriate as part of the engineering design, which will incorporate the above requirements. Specific areas should be assigned to different borrow material types, based on the estimated volumes of a particular material type to be stored at a certain time, the height and slope restrictions of the stockpiles as discussed in the next paragraph, construction considerations such as haul distance from the excavation. The storage area plans should consider the need for access required for drying, as discussed earlier. Consideration should also be given to the reclamation plans discussed in a later section, so that the storage area plans do not interfere with these plans. In general, construction operations should be so planned that except for the topsoil, the required stockpile areas are minimized.

The stockpiles at the WSCA should not have slopes steeper than 1.5(H):1(V) and should not be higher than 15 ft. The stockpiles of uncompacted fill material, wherever maintained, should be placed by spreading with a bulldozer or scraper and trackwalking. Lift thickness

before compaction shall not exceed 1-ft. Compaction should be accomplished by routing of hauling and spreading equipment units.

The stockpile areas should be protected from wind erosion and excessive storm water erosion. Erosion control may be effected by spraying water containing additives or by covering exposed surfaces with geotextile fabric. Temporary seeding, including hydroseeding, may be used for the stored topsoil.

Appropriate dust control measures should be implemented to prevent dust emanating from the stockpiles. The requirements for dust control should conform to the requirements of the HASP for the project as discussed in Section 6.1.7.2.

Excavation and/or processing of excess borrow material should be minimized by proper planning and coordination with ongoing and future construction activities. Nevertheless, some excess borrow material will be left over at the end of construction. The borrow materials left over at the WSCA should be used up during site grading and reclamation to the maximum extent possible. All excess material produced from commercial sources will remain at the source (if it is stockpiled there), or returned to the appropriate source, if already at the CMSA. Appropriate cost adjustments will be made for this effort with the authority of the commercial source.

6.1.7.6 Placement. Placement requirements for a given design requirement should be carefully selected so that the material characteristics achieve the desired function and performance requirements. Placement requirements include density and moisture content at which the material shall be placed, the compaction equipment recommended, the method of placement, and the placement thickness. Based on the above, the materials may be subdivided into six broad categories for placement requirements: (1) low-permeability materials, (2) filter/drain/bedding, (3) riprap and biointrusion, (4) vegetated cover layers, (5) base and subbase, (6) CFD, and (7) site reclamation. Requirements for each broad category are discussed below in detail.

The placement discussions below deal with uncontaminated materials, which should remain uncontaminated after placement; therefore, care should be taken to plan the operations, in order to avoid contaminating these materials.

6.1.7.6.1 Low-Permeability Borrow Materials. Placement density and moisture content are key requirements for the low-permeability materials: clay bottom liner, radon barrier infiltration barrier, and disposal facility foundation improvement soils. This is predicated upon the stringent requirements for low permeability for the in place materials. Ongoing studies (*Supporting Studies 5A* (Ref. 51) and *Supporting Study 8A* (Ref. 53) [in progress]) will determine the required in-place densities and moisture contents. However, based on initial information and past experiences, the following preliminary recommendations can be made.

Material	Required Density ^(a) during Placement	Required Moisture Content during placement	Remarks
Clay Bottom (including foundation improvement soils)	95%	Optimum Moisture Content (OMC) ^(b) plus 0 to 3%	
Infiltration Barrier	100%	Same as above	Most likely will require addition of bentonite
Radon Barrier	95%	Same as above	

(a) Expressed as percentage of maximum dry density as determined by modified Proctor test (ASTM D1557).

(b) As determined by modified Proctor test (ASTM D1557).

All compaction for low-permeability borrow materials should be performed with tamping foot (kneading) compactors. The material should be spread out uniformly, with a loose lift thickness of 8 in. or less. The placed soil should be preprocessed (prior to placement), if required, so that the clod sizes in the placed material are less than 1 in. and the moisture content is within 3% (plus or minus) of the desired range. Ideally, the preprocessing should be performed in the WSCA borrow source. Additional moisture conditioning (wetting or drying) should be performed after placement at the final location.

Concurrently, field and laboratory tests will be performed with the compaction to determine if the placement meets the desired conditions. Field moisture and density tests should be performed by nuclear gauge (ASTM D2427 and ASTM D3017). These test results should then be compared with moisture density tests performed in the field laboratory on the same material, using the modified Proctor method (ASTM D1557). If the field measurements indicate that the density or moisture content requirements are not met, appropriate corrective action should be taken. Corrective measures should be developed in the final design. In extreme cases, the layer may have to be excavated, reworked, and recompacted. After a layer is placed and compacted to satisfaction, the top of the layer should be scarified prior to placement of the

next layer for compaction. All compacted surfaces should be protected against drying. Compacted surfaces should not be left exposed for more than 24 hours. The exposure time should be reduced if evidence of drying is visible.

6.1.7.6.2 Filter/Drain/Bedding Layers. These materials are predominantly sandy materials ranging from silty sands to sandy gravels. There should be no placement density or moisture content requirements for these materials. Except where placed on top of a membrane liner, these materials should be placed in lifts not exceeding 6 in. in thickness and should be compacted by two passes of a 2-ton to 3-ton working weight of a smooth drum vibratory roller. For materials placed on top of a membrane liner, a loose lift thickness at least 12 in. should be used, and compaction should be performed by two complete coverages by any equipment delivering a foot pressure not exceeding 6 psi.

6.1.7.6.3 Riprap and Biointrusion Layers for the Disposal Cell. There is no placement density or moisture content requirements for the riprap or biointrusion rocks. The material may be placed by end dumping and may be spread by bulldozers or other suitable equipment. It should not be dropped because this could damage the underlying placed material or the rock itself.

Riprap or biointrusion material should be placed so that the larger pieces are uniformly distributed and the smaller pieces serve to fill the spaces between them forming a well keyed, densely placed mass. This often requires hand placement or individual placement of rock using a loader, particularly for larger rock.

6.1.7.6.4 Vegetated Cover Layers. The placement moisture and density for the vegetated cover layers (the gravelly topsoil and the two layers of rooting medium) will be dictated by agronomic conditions, which have not been finalized. It is expected that the layers (at least the top two) will generally be loosely placed to facilitate vegetative growth. Some minimal compaction will be required for stability. This should be specified by the number of passes of the construction equipment, e.g., two complete overages of a spreader.

6.1.7.6.5 Base and Subbase Layer for Site Roads and CMSA. The base and subbase layers should be placed on suitably prepared subgrade. Applicable procedures, as required by Missouri Department of Transportation, should be used. The materials should be compacted to a density not less than 95% of the dry density as determined by modified Proctor

test (ASTM D1557). Smooth drum vibrating rollers are recommended as compaction for the base and subbase layers.

6.1.7.6.6 Clean Fill Dike. Material for the CFD will be primarily clayey, because it will be from the borrow area. It is expected therefore, that a minimum of 95% of maximum dry density as determined by modified Proctor test (ASTM D1557) will be required, to provide adequate strength against slope failure. A maximum loose lift thickness of 12 in. is recommended. No requirements for placement moisture content and equipment are warranted. The compaction should be tested by field nuclear gauges at the rates of 1,000 cu yd of material placed. Laboratory moisture density tests should be performed at the rate of 20,000 cu yd of material placed.

6.1.7.6.7 Site Reclamation. Site reclamation soils are also expected to be clayey soils, either from on-site sources generated during cell excavation or other activities or from the WSCA borrow source. The fill for site reclamation will require a density of 90% of maximum dry density as determined by modified Proctor test (ASTM D1557). A maximum loose lift thickness of 12 in. is recommended. Field nuclear gage density tests will be required at the rate of one test per 5,000 cu yd of material placed.

6.1.7.7 Site Reclamation of the Borrow Sources. An engineering study is underway to address the detailed development of the borrow source at the WSCA. The study is only in the beginning stages. At the end of the project, the WSCA should be reclaimed and revegetated, however, it appears that the MDOC does not intend to construct a lake in the area as originally planned. The MDOC's long-term plans for this area are to convert it to a combination of woodland/shrub and prairie grass habitat, with a decrease in the amount of leased cropland. This will require grading the site in an appropriate manner (with gentle slopes), according to recommendations of the supporting study currently in progress. The grading plan should consider the natural drainages around the site to ensure that the regional hydrologic setting is not affected. After site grading, a 6-in. layer of topsoil will be placed over the entire area, and the site will be seeded with appropriate vegetation. Thereafter, the sediment control structures will be converted into small impoundments or wetlands, or removed. Finally, the fences and gate around the site will be removed.

All other borrow sources are expected to be commercial sources, and do not require any reclamation plans.

6.1.7.8 Operational Uncertainties. The operational scenarios for sample selection, transportation, storage, and placement of borrow materials discussed in the previous sections involve certain implicit assumptions. Possible deviations in the assumed conditions (operational uncertainties) should be incorporated, as discussed below.

- It is assumed that the weather during the borrow operations (which does not include the mandatory winter shutdown) will not adversely affect these operations. The most prominent weather uncertainty is precipitation (rainfall or snowfall). Tornadoes or high winds are also potential sources of shutdown. During any such event, activities at both the borrow source and the site will likely be shut down. This will affect the schedule, and appropriate adjustments should be incorporated in the construction schedules or equipment selection.
- The availability of approved materials in the recommended borrow sources is a very important assumption in the previous sections. Studies to identify sources of approved materials in adequate volumes will be completed by the time the designs are finalized. These studies are expected to incorporate significant margins for uncertainty, when recommending a borrow source. There is however, a small probability that a sufficient amount of acceptable material will not be available. This may be due to properties revealed by limited testing during the earlier studies that differ considerably from those actually existing in the field; environmental or other regulations changing during the interim period, making the source unsuitable, or insufficient; or, new information obtained during borrow operations limiting further development, (archaeological finds), which would indicate a violation of existing regulations. These situations must be dealt with in an expeditious manner. As soon as a design is nearly finalized, the assumptions for the borrow sources will be reevaluated to confirm whether the recommendations still hold. Additionally, alternative sources will be identified and made ready as soon as the primary source starts to show signs of depletion.
- Delivery complications (other than weather) may arise, such as transportation workers' strikes, damage to highways due to natural disasters (e.g., earthquakes or tornadoes), changes in local transportation regulations (e.g., allowable weight of trucks), breakdown of equipment, and other factors. Responses to these situations include proper planning to have sufficient borrow material stored on-site at the

CMSA to accommodate delivery delays without compromising the construction schedule. Additional delays or complications could result in a slowdown or shutdown of production at the borrow source, or in providing additional storage area at the borrow source.

- Construction slowdowns may affect the plans for borrow operations discussed in previous sections. Slowdowns may arise due to weather, slowdown of the treatment processes, either chemical stabilization/solidification (CSS) or vitrification (VIT), significant increase in the waste quantity over that originally estimated, regulatory action, or other factors. These factors will consequently affect the placement schedules for the different borrow materials. The revised placement schedules should be reflected in revised borrow delivery schedules and possibly in the borrow production and storage schedules.

6.1.7.9 Specifications. Following is an outline of the specification items associated with the functional aspects of borrow operations:

1. Borrow material production

- For the Weldon Spring Wildlife Area borrow source:
 - Qualifications of PMC's designated representative; his role and authority.
 - Required permits (e.g., National Pollutant Discharge Elimination System [NPDES] permit).
 - Site preparation: fencing and gates, site roads, site clearing.
 - Erosion, dust, and noise control during construction.
 - Excavation, including protection of excavated slopes,
 - Description of different types of material to be excavated and separated.
 - Requirements for additional processing and methods.

- Site reclamation at end of project, including seeding.

- For commercial sources:

- Qualifications of PMC's designated representative; his role and authority.
- Location of facility and formations to be used in the rock.

2. Monitoring of borrow material production (at the borrow source) should include:

- Frequency of field sampling and testing.
- Required properties for acceptability.
- Criteria for acceptance/rejection.
- Actions undertaken upon rejection.
- Protection/prevention from contamination (for on-site sources).

3. Transportation of the borrow materials from the borrow source to the point of placement should include:

- Acceptable modes of transportation.
- Proposed route, e.g., construction haul road for low permeability and CFD materials.
- Dust control and other required controls during transit.

4. Storage of the materials at the borrow source and the CMSA should include:

- Storage area security system.
- Storage area designation.
- Storage strategy - when to store at an off-site source; when to store at the CMSA.
- Height and slope limitations of stockpiles.

- Dust and erosion controls.
- Disposal of stored material at end of project.

5. Placement of the various borrow material types at their final location should include:

For all types of materials:

- Dust control.
- Protection from contaminants.
- Protection after construction.

Low-permeability borrow materials:

- Required density and moisture content, including tolerances.
- Frequency of testing to ensure requirements are met.
- Type of compaction equipment.
- Required preprocessing of soil (clod size, moisture content, etc.).
- Lift thickness.
- Corrective action in the event of not meeting the requirements.
- Other requirements, e.g., scarifying before placement of next lift.
- Protection of the constructed layers.
- Equipment requirements/restrictions

Filter/drain/bedding layers:

- Lift thickness.
- Compaction equipment and number of passes.
- Other placement requirements.

Riprap and biointrusion layers:

- Acceptable method of placement.
- Other requirements: avoid segregation of rock sizes.

Base and subbase:

- Subgrade preparation.
- Required dry density.
- Applicable requirements of Missouri Department of Transportation.

CFD and site reclamation:

- Required density.
- Maximum lift thickness.
- Field testing frequencies.

6. Operational uncertainties should include directives for revisions and corrective measures in the event of:

- Shutdowns and disruptions due to weather.
- Evidence of archaeological sites obtained during borrow operations.
- Unavailability of sufficient appropriate materials.
- Delivery complications.
- Construction slowdowns.

6.1.7.10 Borrow Operations Systems Analysis. The borrow operations are closely tied to other activities at the site. In general, initial demand for borrow materials will be for the foundation preparation activities (e.g., backfilling the holes left by excavation of foundations, sewer lines, and contaminated soils). Borrow will be obtained primarily from the WSCA and transported to the site by off-highway vehicles. The borrow material for the CFD will come from on-site clean material and from the WSCA borrow source. The vehicles will travel by a haul road (to be constructed), crossing under Missouri State Route 94. Therefore, the haul road must be completed before the scheduled placement of material for the dike. Delays in completion of the haul road will cause delays in the backfilling of excavations and the construction of the CFD.

There will be a major demand for borrow materials during construction of the disposal cell cover (cell closure). This involves placement of the radon/infiltration barrier and various other cover components (Table 5.1.7-1). For ease of construction, the practice will be to place

large layers of a single material at one time. This will help in the planning of the borrow production and delivery. A notable exception to this general practice will be when expeditious radon barrier placement is dictated by considerations of radon exposure reduction. Under such situations, a covering layer to protect the radon barrier should also be placed expeditiously.

The demand for borrow materials may be revised if it becomes apparent that Phase III (closure phase) will not be required. Quantities and delivery schedules will then be revised accordingly.

These plans are all based on a certain volume of waste and a 50% contingency. If the waste volumes are significantly larger than those presently planned, there will be considerable impact on the cell design and the required borrow material volumes. This will be realized, as waste processing and placement progresses. Appropriate revisions in borrow operations will then have to be made expeditiously.

6.1.8 Other Facilities

The following are brief descriptions of the steps necessary to construct and operate other facilities. These facilities, specifications, and functional issues are identified and discussed in Section 5.1.8. The schedule for construction and operation of these facilities is shown below.

Schedule for Design and Construction of Other Facilities

Activity	Construction Year
Upgrade electrical system	Sequence 1
Extend water system	Sequence 1
Analytical and QC/PT laboratories	Sequence 0
Leachate collection tank	Sequence 6
Sea-Land container pad extension	As Needed
Controlled area parking	Sequence 1
Contaminated equipment construction area	Sequence 2
Water-truck filling station	Sequence 1
Field shelters	Sequence 1
Vicinity property support facilities	Sequence 4
Training facility	Sequence 0

Notes:

Sequence 0 is beginning of chemical plant foundation removal.
 Sequence 1 is Phase I of the disposal cell.
 Sequence 2 is Phase II of the clean fill dikes.
 Sequence 3 is Phase I of disposal cell is completed.
 Sequence 4 is Phase III of the clean fill dikes.
 Sequence 5 is waste placement in Phase III.
 Sequence 6 is cell closure.

Upgrade existing electrical distribution system. Improvements and extensions to the site electrical system should be installed using a conventional construction method. Work permits may be required from Union Electric Company and the subcontractor will be responsible for acquiring these permits.

Install natural gas supply lines and connection to existing natural gas mainlines. Conventional construction methods should be used to install natural gas distribution facilities. Work permits may be required from Laclede Gas Company and the subcontractor will acquire these permits (VIT alternative only).

Extend existing water distribution system. Conventional construction methods should be used to install extensions to the site water distribution system. Work permits may be required from the St. Charles Water Company, if additional connections to water mains in Missouri State Route 94 right-of-way are necessary. The subcontractor will acquire these permits.

Maintain and protect existing administration area storm water collection system. Although no improvements to the administration area storm water collection system are necessary, it must be protected and maintained during waste removal and disposal cell construction operations. Particular attention should be given to maintaining and protecting this system during the removal of underground utilities and the remediation of Frog Pond.

Construct analytical and QC/physical testing laboratories. These facilities should be mobile or modular structures. Conventional construction methods should be used for furnishing utility services, site preparation, grading and drainage, placing of structural fill, and constructing foundations and structures. Mobile and modular structures must be properly anchored as required by the Building Officials and Code Administrators (BOCA) code.

Extend existing Sea-Land container support pad. If additional Sea-Land containers are needed, the gravel pad that supports the existing containers may need to be expanded.

Conventional construction methods should be used to expand the pad. Sea-Land containers must be properly anchored to resist wind loads, as required by the BOCA code.

Install controlled area parking areas. Several small areas should be developed for parking within the controlled area. These areas should be graded and graveled, and precast-concrete wheel stops should be installed to mark spaces. Conventional construction methods should be used to construct parking areas.

Construct contaminated construction equipment staging area. An area should be developed to provide a place for subcontractors to perform major maintenance on construction equipment. Subcontractor should submit operating plans for its use of the area and should construct and remove whatever facilities may be required for maintenance operations. Gravel surfacing, area lighting, perimeter fencing, a gross decontamination pad, electricity, and water should be installed in the area. The area should be removed when the MSA is removed. Conventional construction methods should be used to build these facilities.

Install a water-truck filling station near the CMSA to serve clean and contaminated trucks. A water-truck filling station to serve clean and contaminated water-trucks should be installed near the CMSA. The station should be positioned on a border between clean and dirty areas to allow access to both clean and dirty trucks. Conventional construction methods should be used to construct this facility.

Install field shelters. Field shelter should be portable temporary structures and should be properly anchored to the ground, as required by the BOCA code. Grading and drainage should be provided, and gravel surfacing should be installed around the structures. Conventional construction methods should be used to construct this facility.

Install vicinity property support facilities. Temporary facilities will be required to support operations at the vicinity properties. Personnel support facilities should include showers, lunch rooms, rest rooms, and work rest area. Decontamination pads, drainage control, area lighting, and security will be necessary. Conventional construction methods should be used to build these facilities.

Construct alternative training facility. This facility should be a modular structure. Conventional construction methods should be used including furnishing utility services, site

preparation, grading and drainage, placement of structural fill, construction of foundations, and structures. Modular structures must be properly anchored, as required by the BOCA code.

6.2 Disposal Facility

6.2.1 General

The construction and operation of the disposal cell during remedial action will require considerable coordination with and sequencing among various cell components and other site features such as site roads, the SWTP, the TSA, the MSA, and the CMSA. Details of construction activities for each major cell component are presented in Sections 6.2.2 through 6.2.6. Cell drainage and water management, and operation and maintenance requirements during cell construction are described in Sections 6.2.7 and 6.2.8, respectively.

The disposal cell will be constructed in three phases (two phases for the VIT option cell). Each phase may include, in rough sequential order, the following construction activities:

- Foundation preparation
- Basal liner and leachate collection and remedial system construction
- CFD construction
- Waste placement
- Interim or permanent cover construction
- Cell drainage during construction

Each construction phase is scheduled to require from 2.5 years to 3 years to complete - overlapping of some activities between phases is anticipated. For example, the Phase II foundation preparation will begin while Phase I waste placement is still underway.

Scheduling of construction operations is largely based on the rate of waste delivery from the waste removal, treatment, and stockpiling operations. It also depends on stockpiling facilities and delivery rates for on-site and off-site borrow materials. The use of a reasonable amount of labor and equipment is assumed. The tentative construction schedule for the CSS alternative is presented in the CSD. The total duration of cell construction for the CSS alternative is six years, beginning with foundation preparation through the completion of cell closure activities. For the VIT alternative, the duration is 9 years. Figures 5.2.9-4 and 5.2.9-5

show the possible demarcation line between Phases I and II and between Phases II and III, respectively. Details on waste placement phasing, construction sequencing, and scheduling are discussed in Sections 6.2.5 and 6.2.7.

Possible operational scenarios for constructing each major cell component are discussed in various subsections of Section 6.

An outline of specifications for cell construction is included in Section 6.2.9.

6.2.2 Cell Siting

This section describes the construction sequencing as it relates to cell siting and the impact of concurrent construction operations on the cell siting process. The cell construction schedule must be coordinated with the WSSRAP integrated schedule for waste excavation, treatment, and placement and for cell construction (Ref. 71).

Construction sequencing must be considered when identifying a potential cell location. Construction operations related to cell siting include:

- Site preparation, including clearing and grubbing, and chipping and piling of vegetation.
- Building demolition.
- Bulk waste removal, including excavating, sorting, and stockpiling of on-site contaminated and uncontaminated soils, existing building foundations/utilities, and debris.
- Excavation for cell foundation.
- Construction, management, and use of the CMSA and other facilities such as site roads and retention ponds.
- Removal of the MSA.

- Final grading around toe of cell.

Due to limited areas available for the storage of construction and waste materials at the Weldon Spring site, storage areas such as the MSA will be located within the disposal cell footprint. Therefore, cell construction will be phased to avoid interference, to allow better operation and maintenance, and to provide better water management during construction operations. The number of phases required to construct the cell depends on the waste volume, the selected waste treatment method, and construction sequencing. Increasing the number of phases may increase the complexity of construction sequencing. Reducing the number of phases may lengthen construction time. The construction phases (either Phase II or III) proposed for the site, are outlined below (see also Section 5.2.9):

- Phase I: Cell construction will start from the southern end of the siting area and will move northward. The Phase I cell site will be cleared prior to the start of cell construction. Building demolition and excavation of contaminated or otherwise unsuitable materials will either be completed prior to initiating cell construction or will be sequenced to avoid interference. Once the site is cleared, grading including backfilling of excavations, will take place, followed by the construction of the CFD, the cell foundation, and the LCRS. Uncontaminated general fill from on-site excavations can either be stockpiled or directly transported for use in the construction of the CFD. Additional material, as required, will be supplied from the off-site borrow source. There are two scenarios for waste placement. The first alternative requires the completion of the lower portion (about mid height) of Phase I of the CFD to the elevation where the outermost limit of waste will be located. Construction of the remaining upper portion of the CFD will take place concurrently with waste placement or preferably, after the waste placement has reached its design elevation. The second alternative requires the construction of the CFD and placement of the waste to occur concurrently. The first scenario reduces worker radiation and chemical exposure, avoids mixing uncontaminated and contaminated materials, and requires simpler construction sequencing. Since the first scenario is safer and simpler than the second, it is recommended as the preferred alternative.

Once the CFD and wastes are in place, the cell cover system, including the filter layer, radon barrier, and rock or vegetated cover can be constructed according to

standard construction procedures. After the placed waste reaches the desired height, Phase II construction can begin.

- Phase II: Phase II construction sequencing is similar to that of Phase I, including completion of the CFD before waste placement starts.
- Phase III (closure phase): The construction sequence of this phase, if required for the CSS alternative, will be similar to Phase II.
- Based on the latest available data, the two-phase option is preferred for the VIT cell and the three-phase option for the CSS cell.
- If the disposal cell location overlaps the CMSA area, cell construction in that area will be delayed until the materials stored at the overlap area of the CMSA are removed.

6.2.3 Preparation of Foundation

6.2.3.1 General. In addition to the disposal cell footprint area, preparation of the disposal cell foundation will include an area up to 50 ft outside the exterior toe of the CFD. Preparation of the disposal cell foundation, in sequential order, comprises clearing, including grubbing and stockpiling of existing and new debris and all vegetation, roots, and organic-laden materials; excavation and stockpiling of buried debris, foundation structures and underground utilities from abandoned buildings, and contaminated materials; excavation and stockpiling of clean (suitable or unsuitable) soils; implementing measures to either continue operating or close existing monitoring wells within the cell footprint; and placement, compaction and grading of fill materials to the design foundation elevation. Details of excavation and removal of contaminated materials, foundations and underground utilities from abandoned buildings are discussed in Sections 6.1.2 and 6.1.3. Disposal cell foundation contours are shown in Figures 5.2.3-2 and 5.2.3-16 for CSS and VIT partially below grade cell foundation excavation, respectively. Details of operation and closure of existing monitoring wells within the disposal cell footprint are discussed in Section 6.4.5. Details of the cell foundation preparation are described below.

6.2.3.2 Site Preparation. Prior to the placement of liner materials, the site will be cleared of all existing debris, vegetation, roots, and organic-laden materials. All vegetation, roots, and organic materials, contaminated or not, will be separated from other debris for biological decomposition prior to being placed in the disposal cell.

All footings, buried foundations and debris, and underground utilities from the abandoned buildings will be excavated and stockpiled for later disposal. All existing contaminated materials within the disposal cell footprint, including those near the ground surface and surrounding the underground sewer lines, will be excavated and stockpiled for later disposal. Details of the above waste removal and handling operations are discussed in Sections 6.1.2 and 6.1.3. The topsoil and most of the existing fill were found to contain debris and vegetative matters. The underlying loess layer contains some very sandy, silty loess (ML and MH) materials (assumed to comprise 25% of the loess layer) that are both soft and loose. From the compressibility and permeability standpoints, these materials are considered to be unsuitable for the disposal cell foundation and therefore must be removed. In addition to the excavation of existing contaminated soils on the southeastern side, all the unsuitable topsoil and existing fill and some localized soft and loose zones of sandy and silty loess (ML and MH) materials within the disposal cell foundation must be removed and replaced with select compacted engineered low-permeability backfill to the bottom of the design cell foundation.

For areas beneath the CFD lower interior sideslope, a 20-ft-thick zone consisting of select compacted engineered low-permeability materials must be placed directly beneath the liner and leachate collection system on the CFD lower interior sideslope, extending to the top of Ferrelview clay, as illustrated in Figure 5.2.3-5. All unsuitable topsoil, existing fill and loess materials within this zone must be removed. By introducing this zone and extending it to the top of the Ferrelview clay along the perimeter of the CFD lower interior sideslope, the entire disposal cell foundation will effectively be sealed off by low-permeability soils, to meet the minimum 20-ft thickness requirement.

Because the remaining CFD foundation area (i.e., from beneath the 20-ft-thick zone to the exterior toe line of the CFD) is considered to be less critical in terms of differential settlements and permeability as compared to the disposal cell foundation, the criterion for removal of unsuitable materials is less stringent - only localized zones consisting of soft and loose materials encountered at the CFD foundation surface will be removed and replaced by compacted engineered backfill materials. The extent and depth of excavation for the removal

of these localized soft and loose materials will be determined by a competent field engineer during excavation and removal operations.

All excavation and trenching for the removal of clean and contaminated soils, abandoned building foundations, underground utilities and test pits for in situ testing will follow Occupational Safety and Health Administration (OSHA) requirements (29 CFR, Part 1926) as discussed in Section 6.1.2.2. For excavation depths between 4 ft and 20 ft, it is recommended that sideslopes be no steeper than 1H:1V from the ground surface to the bottom of existing fill/loess layer (OSHA Type B soil). Excavation side slopes within the underlying stiff clayey soil layers (OSHA Type A soil) will be no steeper than 0.75H:1V. Furthermore, sideslopes will be benched in accordance with OSHA requirements (29 CFR Part 1926) to achieve better compaction and blending of the backfill and soil interface. The bottom width of excavations (including confined areas) within the disposal cell foundation will be widened to accommodate heavy earthmoving and compaction equipment.

After excavation and removal of contaminated materials near the ground surface, if the foundation soils require improvement to enhance permeability performance, as discussed in Section 5.2.4.5, the area beneath the cell bottom liner will be excavated to 5 ft below the final foundation design grade. All clean, acceptable, over-excavated materials may be stockpiled for backfill materials. This excavated area will be backfilled with compacted engineered low-permeability materials to the final foundation elevations as shown in Figure 5.2.3-2 for the CSS cell and Figure 5.2.3-18 for the VIT cell. All backfill and fill materials for areas within the disposal cell foundation and the 20-ft-thick zone beneath the CFD lower interior sideslope will be limited to good quality low-permeability soils obtained from the approved off-site borrow source recommended in *Supporting Study 5A* (Ref. 51) (in progress). The backfill and fill materials for the CFD foundation area can be either clean and suitable materials obtained from excavation operations within the disposal cell foundation or suitable material from the approved off-site borrow source. Prior to the placement of backfill or fill materials, all excavated surfaces will be scarified to a minimum depth of 6 in., brought to a moisture content ranging from 0% to 3% over the optimum, and then compacted to a minimum of 95% of the maximum dry density as determined in the laboratory based on the modified Proctor compaction test (ASTM D1557). All backfill materials will then be placed in lifts not exceeding 8 in. of uncompacted thickness. Each lift will be brought to a moisture content ranging from 0% to 3% above the optimum and compacted to a minimum degree of compaction of 95% as determined by modified Proctor (ASTM D1557). A greater degree of compaction and moisture content may

be required if very low permeability is required. The above compaction requirements are recommended for conceptual design only and are based on engineering experience from previous projects of a similar nature. Such recommendations will be substantiated in Title II design when *Supporting Study No. 8A - Low-Permeability Compaction Test Fill* (Ref. 52) is completed. Criteria for placement of backfill outside the disposal facility foundation are presented in Section 6.1.2.

Major construction operations include stripping, excavating, backfilling, and compacting. Stripping of topsoil and debris will require dozers and loaders. Excavating clean soils to the required elevation will require dozers, scrapers, and backhoes. Backfilling clean soils will require loaders and scrapers, and compacting backfill and fill materials will require sheepsfoot rollers and graders. The use of hand compaction techniques and equipment is specifically excluded in order to reduce the potential for soil macrostructure destruction and creation of preferential flow pathways. Construction operations, in sequential order, and related equipment are summarized in Table 6.2.3-1 (Ref. 115).

Dust control measures will be implemented during site preparation. Such measures will include regular spraying with water and/or dust control surfactants and suppressants. Details of various dust control methods and criteria are described in a study by Morrison Knudsen Corporation Environmental Services Division (Ref. 56). In most cases, the standard dust control methods adopted by the PMC will be appropriate. Where possible and before beginning any excavation, positive measures will be taken to control surface drainage and to minimize the potential for erosion of excavated slopes. Section 6.1.6 details the operations of temporary and permanent drainage features.

6.2.3.3 Bedrock Stability. Based on geotechnical investigations conducted by the PMC in 1990 and geotechnical characterization by MK-Environmental Services (Ref. 18), competent bedrock elevation ranges from 630 ft (mean sea level [MSL]) near the south end to 590 ft (MSL) near the north end of the disposal cell footprint. Figure 6.2.3-1 shows the top of bedrock elevation contours, and Figure 6.2.3-2 shows isopachs of top of Ferrelview clay to top of bedrock. Although both contaminated and clean soils will be excavated during removal of buried debris and deep foundations and the disposal cell layout and require excavation of the foundations soils, there will be no excavation into bedrock. However, some large-diameter piers which bear on, or extend into, bedrock may exist beneath abandoned buildings. The exact nature and depths of embedment and whether the surrounding soils and bedrock are contaminated

remains unknown. Such situations, if encountered during the removal operations, will be handled on a case-by-case basis. The method will depend upon the degree of contamination in bedrock. The PMC will determine the criteria for the removal method.

6.2.3.4 Soil Characterization. Available information and soil data from borings, trenches, field measurements (e.g., soil blow-count values and penetrometer readings) and laboratory tests (Ref. 17 and Ref. 18) are considered adequate for characterizing the soils underlying the disposal cell foundation for the *Conceptual Design Report* (CDR). However, a few additional borings and laboratory and field tests may be required prior to or during Title II design. In general, most of the excavated clean foundation soils are suitable for use as backfill and fill materials. However, due to the low-permeability requirement for the cell foundation, the sandy and silty loess and existing fill layers close to the ground surface are not suitable for foundation backfill. These materials are only suitable as CFD material. All clean clayey soils with the characteristics specified in Section 5.2.4, such as the Ferrelview clay and clay till, are considered to be suitable as foundation backfill.

Characterization of borrow soils from the potential borrow source for low-permeability material is in progress and will be presented in *Supporting Studies 5A* (Ref. 51) and *Supporting Study 8A* (Ref. 53) in progress. Based on preliminary laboratory test results from Supporting Study 5A, soils from the potential borrow source are expected to be suitable for cell foundation backfill and for clay liner, radon barrier, infiltration barrier and CFD construction. Unless the results of further laboratory and test fill permeability tests show that the borrow soils do not meet the design criteria, additional investigations (in terms of soil amendment or selection of another borrow source) are not required.

For significant volumes of backfill and fill materials with natural moisture contents greater than that specified for compaction, a large area will be required for air drying. During the drying process, all clods will be broken down into small-sized chunks by a disk harrow and spread over a large area for air drying until moisture contents fall within the required range. This drying process can be very time consuming and costly; therefore, handling of the wet materials will require special planning and scheduling. The portion of the potential borrow area property not required for borrow material excavation may be large enough to use for air drying.

6.2.3.5 Groundwater Concerns. Groundwater at the site is present in the bedrock aquifer comprising an upper zone of weathered limestone and a lower zone of competent

limestone at elevations from 590 ft to 610 ft (MSL) (Ref. 17). The potential for encountering groundwater from the bedrock aquifer in shallow excavations is considered low, compared to the potential in deep excavations that will be required for removal of deep foundations and contaminated soils. If this water is encountered, the corrective action could be to dewater the excavation by simple pumping or by using pumping wells to lower the phreatic surface in the immediate area prior to the placement of engineered fill.

In addition, areas of perched groundwater are encountered in some localized areas at elevations ranging from 520 ft to 640 ft (MSL) in soil units overlying bedrock (Ref. 17). The potential of encountering perched groundwater in shallow excavations is considered moderate to likely. The source of this water within the cell footprint could be dewatered by simple pumping. In addition, saturated soils considered unsuitable for the disposal cell foundation will also be removed. For areas with a source outside the cell footprint, notably the northeast corner of Raffinate Pit 3 west of the cell footprint, specific control measures may be employed to isolate the source during cell construction. This could include design contingencies such as maintaining a cutoff wall or interceptor trench until the source is eliminated.

Should any groundwater be encountered during deep excavation of contaminated soils, groundwater which could be contaminated will be immediately tested at the site for the degree of contamination and then managed in accordance with the WSSRAP water management plan.

6.2.3.6 Earthwork. The sequence and methods of construction for foundation preparation involving earthwork are described in Section 6.2.3.2 and summarized in Table 6.2.3-1 (Ref. 60). Waste types and volumes for both the CSS and VIT waste treatment alternatives are summarized in Table 6.2.5-1. The excavated (cut) materials are considered to be clean and suitable for CFD foundation backfill and CFD construction. Currently, there appears to be a surplus of excavated materials after the foundation is backfilled. Any suitable materials from this surplus will be stockpiled and reserved for use in CFD construction.

During some field investigations in the disposal cell footprint, excavation of contaminated material in the area of the site water treatment plant, and earthwork operations on the TSA foundation, perched water above the Ferrelview clay and near saturated soils was encountered in isolated locations. When encountered, water is usually perched at the base of fill soils on the underlying natural clays. While it is not practical to determine the extent of such conditions prior to construction, earthwork operations should be planned to deal with such random

occurrences. Air drying of larger volumes of soil is practical, depending on weather conditions and the availability of sufficient area for this operation. Wasting small quantities of material that are too wet may sometimes be more cost effective than drying. Overexcavation and/or localized dewatering of seeps should be expected. Exact remedies will depend on the conditions encountered. Soft subgrade may also require overexcavation and replacement of foundation soils in some areas, particularly those areas around the northeast corner of Raffinate Pit 3 where some seepage was encountered at the dike.

6.2.3.7 Soil Testing. Visual examination, measurements, and testing of soils will establish the adequacy of earthwork construction. The extent of inspection and testing will be sufficient to provide adequate quality control, to verify that the requirements of the plans and specifications are met, and to furnish the necessary permanent record. It is also essential that the personnel performing the inspection and testing have the required training and experience.

Inspection and testing will ensure that the backfill foundation materials are satisfactory and are placed and compacted to meet the specifications. Test frequencies for different tests, as detailed in Section 6.1.7.5.1, will be determined, to the extent possible, to ensure the quality of cell foundation construction while not adversely impacting construction schedule, cost, and the performance of other construction activities. The test frequencies recommended in Section 6.1.7.5.1 will be revised during the final design and construction should they be considered impractical or unacceptable.

6.2.3.8 Operational Uncertainties. The most significant operational uncertainty will be encountering groundwater during deep excavation of contaminated soils surrounding underground utilities and sewer lines. A review of water level data, collection of additional data, and design of a dewatering system will be required to reduce the potential impact of this operational uncertainty. There will be operational uncertainties in determining the extent of seepage and the associated contamination for the remedial actions at the northeast corner of Raffinate Pit 3. Details are discussed in Sections 6.2.3.5 and 6.2.3.6. Other operational uncertainties include the segregation of clean and contaminated soils during excavation that will require an intensive monitoring program, and the discovery of previously unidentified contaminated soils and buried objects during excavation. Details regarding the handling of contaminated soils and buried objects are discussed in Sections 6.1.2 and 6.1.3. Based on the conceptual design, the cell toe line on the southeast side will be very close to the extension structure (laboratory) of the existing administration building. A steeper outside cell slope will

be temporarily constructed at that location to allow enough clearance during cell construction. Near the end of the cell construction when the laboratory function is not as critical, the laboratory structure may be removed or relocated prior to the completion of the outside cell slope.

If the soils surrounding the deep foundations of abandoned buildings are found to be uncontaminated, the following foundation removal procedure will be implemented in areas outside the toe line of an imaginary 3H:1V slope projected outward from the outermost limit of the waste. Instead of excavating and trenching the surrounding soils all the way to the bottom of deep foundations for removal, the amount of excavation and trenching can be significantly reduced by stopping the excavation at a shallower depth, cutting the protruding part of the deep foundations, and leaving the remaining part in-place. If this option is selected, a certain thickness (to be determined during Title II design) of cell foundation soils will be required to be placed on top of the remaining building foundations prior to construction of the CFD.

6.2.4 Liner and Leachate Collection And Removal Systems

6.2.4.1 General. A construction quality assurance/quality control plan is extremely important in producing liner and leachate collection and removal systems that function effectively. The construction sequence and methods used for these system components are listed below in sequential order. Traffic over placed materials should be minimized throughout the construction process to avoid component wear, movement, and damage. Details of the individual components and operations are also included in the following discussion.

- **Subgrade preparation:** Prior to construction of the secondary composite liner, the foundation soils and interior slope of the perimeter CFD must be compacted and prepared to obtain a smooth, flat surface that is free of rocks, sharp protrusions, water, debris, or other deleterious materials.
- **Compacted clay liner:** The compacted clay liner portion of the secondary composite liner is then constructed to the specified lines and grades over the bottom of the disposal cell and over the interior slope of the perimeter CFD. Construction methods and details are covered in Section 6.2.4.1.1.

- **Flexible membrane liner (FML):** Next, the FML is installed over the top of the compacted clay liner. Panels are deployed downslope and seamed by qualified personnel in strict accordance with the manufacturer's specifications. All seams will be independently tested.
- **Geonet drain layer:** The geonet is then placed in panels on the side slopes and overlapped, tied, or seamed in accordance with the manufacturer's specifications.
- **Drain pipe and bedding:** Drain pipes and the coarse gravel drains are installed on the cell bottom. Depending upon the FML thickness and the gravel gradation, a cushion geotextile may be required to protect the FML. Careful compaction of the gravel around pipes is required to provide adequate bedding. Pipe segments must be permanently fastened together as specified by the manufacturer. Pipe slots must be oriented so that the slots are on the bottom half of the pipe. Care must be taken so that the underlying FML is not damaged. Exit point pipes must be installed prior to constructing the clean fill dike.
- **Granular drain layer:** The granular drain material is placed on the bottom of the disposal facility by end-dumping and placement methods which avoid wrinkling and tearing the FML. Careful placement will minimize particle segregation. The granular material should be compacted to at least 70% relative density using a smooth-drum vibratory roller. Care must be taken when compacting close to the side slopes to avoid damaging the geosynthetics.
- **Geotextile filter:** The geotextile filter is placed over the geonets on the side slopes. Panels are seamed by sewing or in accordance with manufacturer's specifications. The geotextile filter should overlap onto the granular drain layer to prevent granular filter material from clogging the geonet.
- **Granular filter layer:** The granular filter layer is placed over the granular drain layer using the same methods and precautions used to place the granular drain layer.
- **Geosynthetic clay liner (GCL):** The GCL portion of the primary composite liner is then placed in panels on the cell bottom and side slopes over the granular and geotextile filters. Panels are overlapped according to the manufacturer's

specifications. The GCL must not be allowed to become wet prior to placing the overlying FML. See Section 6.2.4.1.2 for GCL subgrade preparation.

- Flexible membrane liner: The FML for the primary composite liner is placed as for the geonet drain liner. This primary FML will also be extended up over the waste to meet and be seamed to the cover FML. The geonet and geotextile filter, however, must be placed prior to extending the FML over the waste.
- Geonet
- Granular drain layer
- Geotextile filter
- Granular filter layer
- Holding facilities: During the cell construction phases, the collection pipes must be routed to a temporary holding and treatment system. Once the final phase is completed, the collection pipes must be connected to a manifold and sumps or a retention basin. Basin liners and sump linings should be constructed in accordance with the same stringent quality assurance/quality control criteria used for the disposal facility liners.
- Placement of select waste: A layer of select waste should be placed adjacent to the LCRS to avoid damage to the components. Details of the waste placement operations are presented in Section 6.2.5.

6.2.4.1.1 Compacted Clay Liner. Prior to the placement of compacted clay liner (CCL) material, the side slope CFD material will be scarified to a minimum depth of 6 in., brought to a moisture content ranging from 0% to 3% above optimum, and compacted to a minimum of 95% to 100% of the maximum dry density as determined in the laboratory based on the modified Proctor compaction test (ASTM Test Method D1557). If the side slope is 3H:1V or flatter, all subgrade scarification and compaction and clay liner materials placement and compaction will be operated in the direction of the side slope (up and down slope). However, if a side slope is steeper than 3H:1V, the liner will be constructed by placing

horizontal lifts of clay liner material adjacent to the liner/clean-fill dike interface. Proper bonding between the two materials at the interface will be achieved by using adequate compaction effort, carefully monitored. Construction of the 3-ft-thick compacted clay liner both at the cell bottom and along the clean-fill dike side slope will then follow recommendations specified above, and the types and frequency of tests required for construction quality control will follow recommendations in Section 6.2.3.7. This also applies to the compacted clay liner.

6.2.4.1.2 Geosynthetic Clay Liner. Prior to the placement of a geosynthetic clay liner (GCL), the subgrade will be properly prepared. The subgrade at the cell bottom will be the engineered foundation soil. The prepared surface will be free from loose soil, angular rocks, vegetation, and other foreign matter. All foreign materials and protrusions will be removed, and all cracks and voids will be filled and the surface made level, or evenly sloped, by the required compaction effort. Prior to GCL installation, the subgrade surface will be inspected and approved by the PMC or its representative. The surface on which the GCL is to be placed will be maintained in a firm, clean, dry, and smooth condition during GCL installation.

6.2.4.2 Associated Operations. Operations associated with the construction of the liner system and LCRS include conventional earthwork such as grading, compacting, moisture conditioning, and hauling. Specialized equipment required for seaming and testing the geosynthetics will be required but is usually provided by the installation subcontractor. Granular drain and filter materials will likely need to be custom-graded. If adequate quantities of the proper particle sizes are not available, crushing will be required. All geosynthetics will require protective shelter for storage. Rigorous and continuous inspection and compliance testing will be required during most of the construction operations. Small and light rubber-tired equipment will be required for certain operations where driving directly upon FMLs is unavoidable. Special seaming techniques may be required for boots around pipes that penetrate the liners.

6.2.4.3 Operational Uncertainties. Depending upon the results of liner compatibility testing, a flexible membrane material type, such as chlorosulfonated polyethylene (CSPE) or polyvinyl chloride (PVC), may be the preferred material type. These materials are solvent seamed rather than hot-wedge welded. The solvents may create fumes. During the phased construction of the disposal facility, the pipes and FMLs in adjoining phases will need to be connected. Pipes may require butt welding if snap-together joints are unacceptable. Some worker exposure to leachate may occur. The leachate is currently expected to be relatively

dilute and nonaggressive, but this assumption needs to be confirmed by the results of the ongoing leachate characterization work.

The major concern of liner construction will be the quality control of the GCL installation, particularly the seams between two GCL panels. Placement of materials on top of the GCL will be done with extreme care, since the GCL can be easily smeared and damaged by heavy equipment on top of the GCL. A strict quality control program will therefore be carefully set up to ensure the quality and integrity of the GCL during its installation.

The LCRS will require monitoring and maintenance beginning with the construction phase and continuing through the leachate treatment period. The system can be closed once monitoring and treatment of leachate are no longer required by regulators. During the active maintenance and monitoring period, leachate flow rates and quality must be regularly monitored. Maintenance of components located within the disposal facility is not feasible; however, the redundancy incorporated within the design precludes the need for maintenance. The collection manifold and holding components located outside of the disposal facility will probably require maintenance or replacement during their period of service.

6.2.5 Waste Placement

Waste will be placed in the cell in conformance with the design considerations described in Section 5.2.6. Waste will be placed in a manner that ensures structural stability, minimizes waste volume, protects the environment, and meets health and safety regulations. This section discusses methods of delivery, placement, and densification of the waste, placement sequence, and equipment to be used.

6.2.5.1 General. Waste will be transported to the cell in trucks and unloaded at the approximate location of its final placement. It will be placed in lifts using concrete pumps, loaders, graders, excavators, grapples, and compactors, as applicable. Voids will be minimized to reduce settlement of the cell cover.

The following sections discuss placement methods for each significant waste form. Potential sequences and routing are graphically shown in schematic form. Equipment selection will largely be at the discretion of the subcontractor, but some general criteria are noted. An

overview of waste tracking requirements is given. Finally, operational uncertainties relating to waste placement are discussed.

CSS alternative. For the CSS alternative, most of the Phase I waste will consist of CSS product, metal, and concrete rubble. The grout-like CSS product will be used to entomb metal and concrete wastes. Since the grout will need to be sufficiently fluid to permeate the voids in the metal waste, berms may be needed to contain the grout. These berms may be constructed of compacted contaminated soils, and they may also serve as construction roadways within the cell. In addition, some irregularity of the grouted surface will likely result from large or irregularly-shaped pieces of metal waste (such as old forklifts, vehicles, rebar, and tanks), and compacted contaminated soil may be used to smooth over the irregularities and to protect equipment tires. Section 5.3.4 (Size Reduction) describes in detail the metal, concrete, and other waste forms as they will be delivered to the cell. These are briefly discussed below.

Metal waste will be delivered to the cell in flat-bed or dump trucks and placed in the cell in long rows approximately 30 ft wide. Each row of placed waste should be between 1 ft and 3 ft high (or thick). The thickness for each type of metal waste should be selected to provide for the most efficient packing of the metal. This will minimize the amount of CSS grout required for entombment and promote full penetration of the grout into voids. After being dumped or otherwise removed from the delivery trucks, the metal waste will be carefully placed using grapples, excavators with thumbs, loaders with multi-purpose buckets, or a combination of the above.

Concrete rubble will also be placed in the cell during Phase I and covered with CSS treated waste. A grout-like CSS product is preferred for filling voids, but a soil-like CSS product may also suffice. Depending on early experience with the CSS treated waste and on the projected quantities of grout-like and soil-like CSS products, it may be more advantageous to use a soil-like CSS product to cover the concrete rubble. The concrete rubble should be delivered to the cell and spread in lifts no thicker than 18 in. Concrete rubble larger than 18 in. may be placed in lifts up to 3 ft thick and entombed in CSS grout by pumping the grout into the rubble. The soil-like CSS product, if used, may come in one of two forms. It may be delivered to the cell in a form that is initially too wet to work, and thus would be dumped in heaps and allowed to cure or set overnight (or longer if required). It would then be ripped (if necessary) and moved with a dozer or loader to its proper location, spread, and compacted. Alternatively, the soil-like CSS product may be delivered to the cell in a form similar to a properly moisture-

conditioned soil, and thus would be spread and compacted upon placement. Ongoing treatability tests will better define which soil-like product is most probable for placement.

Figures 5.2.6-1 through 5.2.6-4 illustrate schematic plan views depicting a waste operation designed to achieve homogeneity on a macro scale. Figure 5.2.6-5 shows a schematic cross section of the same operation. These figures are for concurrent placement of metal with CSS grout, concrete rubble with the soil-like CSS product or CSS grout, and contaminated soil and gravel. The scheme may be modified for fewer or more concurrent operations.

Prior to placement in the cell, contaminated soil and gravel should be moisture-conditioned to a moisture content range to be specified following future testing for hydrocompression potential. After delivery to the cell, it should be spread in lifts not exceeding 12 in. in uncompacted thickness, final moisture-conditioned to within the specified moisture range, and compacted using the appropriate equipment.

Waste types and volumes are summarized in Table 6.2.5-1. This table includes in situ volumes and treated volumes for the CSS and VIT alternatives. Contingency volumes are not included, but would affect mainly soils and sediments (Item 2).

VIT alternative. For the VIT alternative, most of the placement criteria are the same as for the CSS alternative. Portions of the metal waste will be entombed in clean grout, as described in Section 5.2.6.2. Voids in the concrete debris and in the remaining metal waste will be filled with contaminated soil, gravel, or vitrified product. The vitrified product will be delivered to the cell in a fritted form in end-dump trucks and then spread and compacted.

Figure 5.2.6-6 shows a schematic cross section of this operation. This figure shows concurrent placement of metal waste, clean grout, concrete debris, vitrified product, and contaminated soil. The scheme may easily be modified for different, fewer, or more concurrent operations at different times during waste placement.

6.2.5.2 Placement Method

6.2.5.2.1 Alternative Evaluation. MVE Table 6.2.5-2 lists the topics and alternatives methods for waste placement. These placement methods are discussed below.

6.2.5.2.2 Details of Preferred Alternatives. For the CSS alternative, placement will be as follows:

- Boom truck and concrete pumps should be used to place the CSS grout in the metal waste in the cell to entomb the waste and fill the primary voids. Alternatively, dumping of CSS grout from dump trucks onto rubble may be an acceptable method of grout placement that ensures filling of voids in the rubble.
- If there is enough grout material to entomb all metal and concrete waste, the voids in concrete rubble should be filled with CSS grout; if there is not, filling the voids in the concrete rubble with soil-like CSS will also be acceptable. Soil will also work as a filler of voids, but some voids will remain and may lead to somewhat greater (but not unmanageable) settlement.
- Friable ACM has been bagged, and during 1992 the bags were placed into Sea-Land containers for storage until placement in the cell. For final placement in the cell, the bags will be removed from the containers, placed in shallow trenches or holes in the cell, and covered with contaminated soil or soil-like CSS product. The placement of ACM may be restricted to certain locations within the cell, to be specified during final design, to prevent its escape to the environment should the cell need to be opened in the future. If there is a way to lift the loaded Sea-Land containers, it may be advantageous to convey the containers to the disposal cell before removing the asbestos to minimize haul distance and to have a single handling operation. Bringing the containers onto the disposal cell may result in additional contamination of the containers. These alternatives should be further evaluated during final design.
- Several alternatives were deemed acceptable for placing pipe waste. Based on this finding, and on the recommendations regarding size reduction (Sections 5.3.4 and 6.3.4), methods of pipe placement are as follows. Large-diameter steel pipe will be crushed, placed in the cell and entombed; reinforced concrete pipe will be separated at joints, placed in the cell on a slope, and filled with CSS grout; cast-iron and clay pipe will be crushed, placed in the cell, and entombed; and smaller-diameter pipe will be placed in the cell and entombed. The CSS product will bridge any voids left by the eventual corrosion of the pipe. The placement method for reinforced concrete pipe will also work for any large tanks or vessels that are not crushed or flattened.

For the VIT alternative, placement will be as follows:

- Clean grout will be used to entomb the metals with large voids. The method of entombment should be the same as for the CSS alternative described above. For other metal waste not requiring grout entombment, the waste should be placed in thin lifts, covered with contaminated soil or vitrified product, and compacted.
- Concrete rubble should be placed in lifts as thin as possible (but no less than about 12 in.) based on the dimension of the rubble, to the maximum number of voids. Each lift should be covered with contaminated soil or vitrified product to fill the voids as thoroughly as possible and compacted.
- The method for disposing of friable ACM will be the same as for the CSS alternative.
- Recommendations for large-diameter pipe will be similar to those for the CSS alternative. Clean grout should be purchased for filling of large-diameter reinforced concrete pipe. Other pipe should be placed as described above and covered with contaminated soil or vitrified product.

Placement methods for each waste form. Placement methods were considered in the *Supporting Study 9a, Waste Form Placement* (Ref. 58). Table 6.2.5-3 summarizes the recommended placement methods for the major waste forms to be placed in the disposal cell.

6.2.5.2.3 Technical Uncertainties. MVE Table 6.2.5-4 shows the application and use of the observational method to the waste placement alternatives. Potential deviations from the expected conditions are listed, and their effects on the design are noted. The primary concerns are to ensure there will be sufficient CSS grout to entomb the concrete rubble, and the potential for bags of friable ACM to burst.

In MVE Table 6.2.5-5, data needed to properly assess technical uncertainties are listed for each area of technical uncertainty. During final design, the expected conditions of the bags containing the friable ACM should be investigated.

6.2.5.3 Placement Sequence

6.2.5.3.1 Evaluation of Alternatives. Placement sequence and schedule were considered in an MVE session on Integrated Schedule for Excavation, Treatment, Placement, and Cell Construction (Ref. 71), and are further discussed in the CSD. Alternatives for the number of shifts for CSS production, ranging from 1 to 3, were identified using a standard MVE format, as shown in MVE Table 6.2.5-6.

6.2.5.3.2 Details of Preferred Alternative. It is recommended that CSS material be produced and placed in two shifts each day. The advantages over a single shift per day include less start-up and shut-down time during shift changes, shorter CSS processing duration, and the ability to keep pace with grouting of placed metal and concrete debris. The disadvantages include the need to maintain a minimal staff of health and safety personnel during a second shift while only a limited amount of work is performed. Three shifts per day would offer advantages similar to two shifts, and further benefit in the ratio between start-up and shut-down time to operation time. However, a third shift is not needed to keep pace with other operations, and production during the third shift may even need to be slowed substantially to synchronize with other operations.

Placement of waste in all forms except CSS entombment of metal waste will be limited to daylight hours. Entombment of metal debris or placement of soil-like CSS may occur at any time.

For the VIT alternative, because vitrification will proceed around the clock, 7 days/week, year-round, all shifts will already be used and additional shifts will not be available. Placement of vitrified product will easily be handled in a single shift per day during the nine month of each construction season. During swing and graveyard shifts, and during the winter, vitrified product will be stockpiled for placement during regular placement operations.

The final disposal cell footprint will cover the area of the existing MSA. It will therefore be necessary to remove all material from the MSA while Phase II is in progress.

After cell construction has begun (and contaminated materials have been removed from beneath the cell footprint), the primary unknown volume of waste (requiring contingency cell capacity) will be the volume beneath the raffinate pits. This is further discussed in

Section 6.1.2.3.4. Early knowledge of the soil volume to be excavated beneath the raffinate pits will permit early refinement of the waste volumes estimate to support adjustment of the cell configuration.

All treated sludges (CSS product) and metals should be placed within the Phase I area of the cell. For the concrete rubble to be entombed with CSS product, all concrete rubble should also be placed during Phase I. If possible, the contaminated soil placed during Phase I should be limited mainly to roads and berms within Phase I.

The initial waste placement operation, following completion of the basal liner and LCRS, will be the placement and compaction of an 18-in. layer of contaminated soil over the LCRS to provide a firm working surface for subsequent operations, to prevent CSS grout from penetrating into the LCRS, to prevent metal waste forms from gouging the LCRS, to minimize runoff into the LCRS, and to establish a relatively impermeable surface over which to direct runoff. This 18-in. layer should be constructed in two lifts. The lower 12-in. lift should be compacted by track-walking or rolling with rubber-tired equipment. The top 6-in. lift should be compacted to 90% of maximum dry density as determined by modified Proctor tests (ASTM D1557). Care should be taken to ensure that the compaction effort will not damage the underlying LCRS.

6.2.5.3.3 Technical Uncertainties. MVE Table 6.2.5-7 shows the application and use of the observational method to the number of CSS production shifts per day. Potential deviations from the expected conditions are listed, and their effect on the design is noted. The primary concerns relate to approval by the ES&H Department, the public, and regulatory agencies.

As discussed in the waste placement supporting study (Ref. 59), the *Resource Conservation and Recovery Act* (RCRA), as amended, states that liquids shall not be placed in a landfill, nor should containers holding free liquids unless all free-standing liquid has been removed, mixed with absorbent or solidified, or otherwise eliminated (Ref. 1). It is not clear how this may affect the placement of CSS, which may still have free liquid at the time of placement (Ref. 31), even though some of the free liquids would be used up in the hydration of the cement and fly ash during the first few weeks following placement. Preliminary discussions of this issue for the *Record of Decision (ROD)*, center on a liquids' waiver for the placement of CSS grout, provided the grout is used to fill voids in the rubble and the liquid is not a RCRA characteristic waste.

As shown in MVE Table 6.2.5-8, data needed to properly assess technical uncertainties are listed. During final design, it will be critical to obtain approval for multiple shifts.

6.2.5.4 Equipment. In general, equipment selection will be at the discretion of the subcontractor as long as it satisfies the performance criteria and placement specifications, subject to approval by the PMC. This section presents some of the criteria that should be used by the subcontractor to select equipment and by the PMC to approve the subcontractor's selections. These criteria include environmental and human safety, local practices, and equipment availability.

Conventional earthwork equipment such as dump trucks, scrapers, dozers, and compactors will be used to deliver, place, and compact contaminated soil.

End-dump trucks will be used to deliver most metal waste. Flat-bed trucks may be used to deliver large metal waste. Excavators with grapple attachments or thumbs will be used to spread and arrange metal waste. A crane may be required to unload some of the heaviest (over 20,000 lb) pieces of metal. Preferably on-site excavators or loaders with chokers will be used to avoid bringing a crane onto the cell.

End-dump trucks will also be used to deliver concrete rubble to the cell, and track-mounted front-end loaders with multi-purpose buckets will be used to spread it in lifts. For the CSS alternative, concrete rubble will be entombed with CSS grout; for the VIT alternative, rubble will be covered and compacted with contaminated soil or gravel or vitrified product.

A concrete boom pump truck or dump truck will be used to place CSS grout. To facilitate placement, a track-mounted excavator equipped with a thumb will be used. The excavator will be able to move the CSS product around, form berms or channels to control the flow of the grout, and manipulate metal waste forms. It will also be able to provide minimal vibration by batting at the metal or CSS to allow the CSS to fill-in the voids of the metal. If additional vibration is needed, a shaker-head or conventional hand-held mechanical vibrator may be attached to the excavator.

End-dump trucks will be used to deliver fritted vitrified product. Track-mounted dozers, loaders, or vibratory rollers (smooth-drum or sheepsfoot) may be used for compaction. Because a vibratory sheepsfoot compactor may have trouble negotiating the irregular surface of concrete

or metal debris, track-mounted dozers or loaders should be used to spread and compact this material.

Placement of soil-like CSS product will depend on the consistency of this waste form, which will be further investigated during pilot-scale testing. If the soil-like CSS is firm enough to compact initially, it will be spread with track-mounted front-end loaders or dozers. Compaction may be possible by either track-walking or using a sheepsfoot compactor. If the soil-like CSS is too soft and wet to compact initially, it may be placed in the cell and allowed to set until firm enough for compaction. It may then be spread and compacted, again by either track-walking or using a sheepsfoot compactor. The material should be compacted to 90% to 95% of maximum dry density as determined by modified Proctor tests (ASTM D1557). (The required relative compaction will be specified based on testing and evaluation for hydrocompression prior to final design.)

Bagged friable ACM will be placed in trenches by hand and then covered with contaminated soil using heavy equipment.

Equipment already at the cell, such as track-mounted loaders, dozers, and excavators, will be used to handle other waste forms not specifically discussed above.

A water truck or water wagon will be required to moisture-condition contaminated soil and to control dust along access routes. A grader will also be required periodically to maintain access routes that are not asphalt surfaced.

6.2.5.5 Waste Tracking Requirements. The volume of waste placed in the cell should be tracked in two ways. First, each day a record of the approximate number or loads or quantities of each waste form should be made, along with the approximate location and elevation at which it was deposited.

Second, a control survey should be made periodically of the surface of the waste pile to determine the actual in-place volume. Large markers, clearly visible from a distance, should be installed around the perimeter of the cell to assist in identifying locations and elevations within the cell. Markers may consist of poles, stakes, signs, or spray-paint on surfaces of the liner or CFD.

Plans, cross sections, and tables summarizing waste placement should be developed and made available at the cell for personnel directing the placement operations.

6.2.5.6 Operational Uncertainty. The primary operational uncertainties of concern at this time are the consistency of the grout-like and soil-like CSS products. The consistency and workability of these materials should be explored during pilot-scale CSS testing.

The above plan has been designed to provide a high degree of flexibility regarding most aspects of the operation. It is expected that equipment will break and be shut down briefly from time to time. Under the current plan, this means that the waste placement work will continue with other waste forms, or that equipment for placement of other waste forms may be shifted to cover for the down equipment. The entire operation may slow slightly during these times, but is expected to continue to progress.

If the CSS treatment plant is down for a short period of time, placement of metal and concrete may precede entombment. However, if downtime extends beyond certain limits, it may be necessary to shift to placement of waste forms other than metal and concrete, such as contaminated soil and gravel, to avoid hampering the placement operations.

The operations will be shut down during the winter. During each month of the construction season (March through November), there are typically six days in which precipitation exceeds 0.1 in., two days exceeding 0.5 in., and one day exceeding 1 in. (Ref. 116). It is likely that some waste placement operations can proceed on days exceeding 0.5 in. of rain, but most operations will be shut down on days with 1.0 in. or more of rain. Days with less than 0.1 in. of precipitation will probably have little impact on the operations. Winterization of the cell is discussed in Sections 5.2.8 (Cell Drainage/Water Management) and 5.2.9 (Operation and Maintenance).

6.2.6 Waste Containment System

6.2.6.1 General. The three major components of the disposal cell waste containment system are the basal liner and LCRS, clean-fill dikes, and the top cover. The CFD for each successive phase of the cell will be constructed prior to the placement of the waste for that phase. The cell cover will be constructed during or after waste placement in successive phases of the cell. Interim covers will be used during construction to control dust and to protect

the components and materials that could be damaged by exposure to inclement weather during winter shutdowns.

6.2.6.2 Clean-Fill Dike Construction. Prior to construction of the CFD, contaminated facilities and soils will be removed and excavations backfilled with compacted fill to the required grade. The dike material will be placed in successive lifts to form the dike. The surface of the lifts will be sloped away from the interior of the cell to prevent runoff from flowing into the cell and potentially affecting basal liners, drains, and wastes that may already be in place.

In addition, the wastes placed adjacent to the clean-fill dikes will be sloped away from the dikes to preclude waste runoff from ponding against or flowing over the clean material of the dikes.

As shown in Figure 6.2.6-1, either a portion of, or the whole dike, may be constructed before waste placement adjacent to the CFD commences. In particular, the outer slopes may, at first, be constructed to slopes of 3H:1V to avoid existing facilities or to provide room for access. At a later stage, after placement of the wastes and the cover for that phase of the cell, the CFD may be flattened to the design outer slope of 5H:1V. Suitable slope protection of the three to one slopes may be required if they are left exposed for an extended period. Protection may be geosynthetics, rock, or simply repair of incipient erosion.

Once the final profile of the CFD has been constructed, the drain and the erosion rock layer will be placed.

6.2.6.3 Cover Construction. The cover will be placed over the graded and compacted wastes (if required for the specific waste form). Cover placement will be phased to correspond to the placement of the waste in the various cell construction phases. As soon as a reasonable area of waste has been brought to final elevation, the radon barrier will be placed over that area. To prevent the radon barrier soils from drying, it will be covered as soon as practical with the bentonite layer (in the geomat) and the geomembrane (the additional infiltration barrier components). The remaining cover components will be placed after placement of the geomembrane; alternatively, they could be placed once the radon and infiltration barrier elements for a complete phase have been installed.

An alternative approach would be to place an interim cover of low radon emanating CSS or clean soil over the wastes brought to their final elevation. Once all the wastes for the specific phase are in place, the radon barrier and successive layers will be placed.

The selection between these alternatives will be based on the economics of the interim cover and the inefficiency of piecemeal construction of the cover.

6.2.6.4 Interim Covers. There will be several winter shutdowns during the construction of the disposal cell. An interim cover will protect from potential damage by freezing and thawing. The preferred interim cover for the wastes is a layer of CSS treated material that is wind and water erosion resistant.

Because freezing and thawing also affects the permeability of the cover infiltration barrier, the entire layering system of the top cover must be in place prior to winter shutdown. Therefore, any cover areas which cannot be totally constructed before freezing conditions occur should be covered with an interim cover until conditions allow for placement of all cover layers in that region.

6.2.6.5 Operational Uncertainties. Uncertainties associated with construction of the CFD and the cover relate to material properties, the weather, the rate of construction, and construction equipment capability. The procedures and requirements for CFD and cover construction described above make reasonable provision for the control of such variables and placement of components in accordance with design requirements and construction specifications.

6.2.7 Cell Drainage and Water Management

During cell construction, the waste surface must be graded to prevent ponding and to drain runoff to the edge of the placed waste. Within the main waste pile, unlined ditches will direct water, as necessary, and protect the waste placement operations. Construction will be performed with dozers and motor graders. Temporary culverts may be needed in some locations to protect roads while facilitating drainage. A collector ditch will be constructed along the toe of the waste slope and lined with a FML. Continuous maintenance will be required during and following heavy rains. Some erosional cutting is expected in the unlined ditches, and rilling and gullying are expected on the waste surfaces. Therefore, some siltation is expected in both the collector ditch and the ponds. Following rains, rills and gullies should be backfilled with

suitable material. Sediments should be removed from drainage channels as frequently as necessary to avoid deterioration of the cell stability or the drainage system capacity. Pumps will be installed and maintained in the APID pond and, possibly, in the runoff collection locations at the edge of the cell. The pumps should be designed to start automatically in response to water levels and should be tested periodically.

Except following the first construction season, during winter shutdowns, nearly all waste in the cell is expected to be covered by the initial lifts of the final cover, which will slope away from the cell and drain over the sides of the CFD. Therefore, during the first winter, it is recommended that the cell be winterized by grading the waste surface to drain to the collection locations along the edge of the waste placement operation. It may be appropriate to place a layer of CSS treated material over the top of the wastes if the CSS product is found to resist erosion. For the VIT alternative, or if a resistant CSS product layer is not used in the CSS alternative, the waste surface should be winterized by spraying a polymeric coating to create a weather-resistant film that will protect against potential erosion caused by wind and rain. The potential use of any erosion control products will have to be evaluated and approved in accordance with procedure RC-15a *Waste Minimization Feasibility Analysis*.

Following any winter shutdown during which a waste surface has been left exposed to weather, the waste surface should be evaluated for loosening due to freezing or frost heave. At a minimum, the waste surface should be scarified and recompact prior to being covered with subsequent lifts of waste.

During the final design effort, drainage within the cell should be coordinated with drainage of the site, treatment operations and schedules, and with other cell and site operations.

6.2.8 Operation and Maintenance

Operations and maintenance requirements are essentially the same for both the CSS and VIT alternatives (see Section 5.2.9). Dust will be controlled primarily by water sprayed from a water truck or water wagon, as discussed in Section 5.2.9. Surveying operations to control and track the wastes are described in Section 6.2.5.5. Drainage operations are described in Section 6.2.7. Most of the cell maintenance requirements are related to water control and are also discussed in Section 6.2.7.

Daily equipment maintenance will be performed within the cell. Major equipment maintenance or repairs will be performed at a location to be selected by the subcontractor and approved by the PMC. Potential locations include the TSA, which will provide a contaminated work area, or the CMSA which will provide an uncontaminated work area.

6.2.9 Outline of Specifications

Detailed specifications for disposal facility construction will be prepared during Title II design. The specifications that will be required for disposal facility construction are shown below. There are two types of specifications. Construction specifications that specify how the cell shall be built are listed in Section 6.2.9.1, and standard specifications for generic testing and manufactured products are listed in Section 6.2.9.2.

6.2.9.1 Construction Specifications. The following specifications will be written specifically for the construction of the on-site disposal cell.

- Site clearing.
- Dewatering and drainage.
- Earthwork (including cell foundation, clay liner, vegetated layer, drainage and filter layers).
- Trench excavation and backfill.
- Test fill (if required).
- Erosion control.
- Erosion protection.
- Geonets.
- Membrane liners.

- Geosynthetic clay liners.
- Geotextile fabrics.
- Seeding.
- Cover vegetation.
- Aggregate drain materials.
- Riprap materials.
- Slotted high density polyethylene (HDPE) drain pipe.
- HDPE Sumps.
- Pumps and piping.
- Waste placement.
- Asbestos placement.

6.2.9.2 Standard Specifications for Generic Testing and Manufactured Products. These standards are reference specifications and guidelines published by various organizations and agencies to insure that specified type and quality of construction materials, such as soils, concrete, and pipes, will meet standard engineering practice and industry standards. Standards of specifications will be referred to in the construction specifications.

- American Society For Testing and Materials

C39 Test for Compressive Strength of Cylindrical Concrete Specimens.

C88 Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

- C109 Test Method for Compressive Strength of Hydraulic Cement Mortars (2-in. or 50-mm Cube Specimens).
- C127 Test for Specific Gravity and Absorption of Coarse Aggregates.
- C131 Test for Resistance to Abrasion of Small Size Course Aggregates by Use of the Los Angeles Machine.
- C143 Test for Slump of Portland Cement Concrete.
- C295 Rec. Practice for Petrographic Examination of Aggregates for Concrete.
- D413 Test Methods for Rubber Property - Adhesion to Flexible Substrate.
- D422 Particle-Size Analysis of Soils.
- D638 Test Method for Tensile Properties of Plastics.
- D698 Test for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb Rammer and 12-in. Drop.
- D751 Method of Testing Coated Fabrics.
- D882 Test Methods for Tensile Properties of Thin Plastic Sheeting.
- D1004 Method for Initial Tear Resistance of Plastic Film and Sheeting.
- D1140 Test for Amount of Material in Soils Finer than the No. 200 Sieve.
- D1556 Test for Density of Soil in Place by the Sand-Cone Method.

- D1557 Test for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb Rammer and 18-in. Drop.
- D1593 Specification for Nonrigid Vinyl Chloride Plastic Sheeting.
- D2167 Test for Density of Soil in Place by the Rubber-Balloon Method.
- D2216 Laboratory Determination of Moisture Content of Soil.
- D2434 Test for Permeability of Granular Soils (Constant Head).
- D2487 Classification of Soils for Engineering Purposes.
- D2488 Rec. Practice for Description of Soils (Visual-Manual Procedures).
- D2922 Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- D2937 Test for Density of Soil in Place by the Drive-Cylinder Method.
- D3017 Test for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- D3083 Specification for Flexible Poly (Vinyl Chloride) Plastic Sheeting for Pond, Canal, and Reservoir Lining.
- D4253 Test Methods for Maximum Index Density of Soils Using a Vibratory Table.
- D4254 Test Methods for Maximum Index Density of Soils and Calculation of Relative Density.
- D4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

D4437

Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

- U.S. Army Corp of Engineers

COE EM 1906, Appendices VII and X: Permeability Tests and Triaxial Compression Tests.

6.3 Waste Treatment and Processing

6.3.1 General

The operational aspects of CSS, VIT, size reduction, dewatering, decontamination, additional treatment and processing and related activities are discussed in the following sections. The design section (Section 5) is driven by performance criteria, and these are achieved through operational methods. This section will detail the operational methods for treating the portions of the waste requiring treatment prior to final disposal in the cell, destruction of the contaminants, or unrestricted release of noncontaminated material.

6.3.2 Chemical Stabilization/Solidification

One of the goals of the CSS plant is to process both raffinate sludge and soils, generating a stabilized waste in the form of either a grout-like or soil-like product. Selected containerized wastes stored in Building 434 may also be treated using CSS depending on future bench scale tests. The treatment plant must process wastes at a rate that allows timely remediation of the site. Specific operational activities associated with CSS treatment include waste preparation, waste and reagent storage, waste and reagent feeding, waste and reagent mixing, and product discharge.

The conceptual design presented in Section 5.3.2 is based on the evaluation of alternatives for these different operational components; recognizing additional requirements for radon control, product quality criteria and quality assurance requirements, worker safety, minimizing any adverse ancillary environmental impacts, and a system capable of handling various operational uncertainties, along with any other operational requirements.

MVE sessions were conducted to identify and evaluate various alternatives for the different design components in a consistent and documented process. The following sections elaborate on the CSS plant operational requirements considered important in evaluating the results of the MVE sessions.

6.3.2.1 General. As noted above, the conceptual CSS facility must accomplish several requirements. The following text provides a general overview of CSS plant operations and their impact on its design.

The operation of the conceptual CSS plant is similar to that of a conventional concrete production plant, where concrete is basically a mixture of two parts: aggregates and paste (binder and water). The paste, comprised of Portland cement and water, binds the aggregates, such as sand and gravel or crushed stone, into a rock-like mass. The paste then hardens because of the chemical reaction between the cement and water. Cement paste ordinarily constitutes about 15% of the total volume of concrete and water constitutes about 21%. In properly made concrete, each particle of aggregate is completely coated with paste, and all of the space between aggregate particles is completely filled with paste.

In the CSS plant, the aggregates and water are substituted by raffinate and/or soils, and the binder is a combination of cement and fly ash. The binder ratio for this process will average 40% cement and 60% fly ash. The quality of this mix has been confirmed by testing in the Waste Technology Group laboratory. The grout-like product, which cures to monolithic form, is produced by combining raffinate sludge and binder using about 29% binder (cement and fly ash) and 70% to 75% sludge. The water content of the raffinate is 70% to 75%. The total water content of the mix is about 54%. Binder ratios and water contents of the wastes to be stabilized are subject to change pending continuing bench scale and future pilot scale testing.

All components must be combined in a manner that produces a homogeneous mix. The sequence of charging ingredients and mixing time plays an important part in the uniformity of the finished product. The sequence, however, can be varied and still produce a quality product, but different sequences may require different mixing times. Other important factors of mixing are the size of the batch in relation to the size of the mixer (drum), mixer rotation speed, and types of mixing blades. The following operational discussions are based on the preferred alternative.

The proposed CSS plant is capable of rapidly producing a large volume of CSS product from a highly variable waste feed. The operation will be a remote, computer-operated system to minimize personnel exposure to hazardous constituents and to facilitate continuous operation under restrictive personal protective equipment (PPE) requirements. The proposed system will also be equipped with in-line instrumentation and a computer-based data acquisition system capable of remote, real-time continuous monitoring and recording of input raffinate sludge, soil, reagent mass, and water content. These features are required to produce a uniform CSS product from the highly variable waste feed.

The storage of waste feed material in solid or liquid form is required to supply the production plant without interruption for 14.5 hour/day. Components such as cement and fly ash will be delivered in trucks. These components will be off-loaded in a manner that minimizes air emissions. The liquids and slurry pumping system must be capable of surge-free starting and must use leak-free pumps.

6.3.2.2 Operation Requirements. The following text presents the specific operations related to the processing of the various Weldon Spring site wastes.

The operation of the CSS plant is dependent upon coordination among the dewatering operation, delivery of wastes to the material preparation circuit, delivery of reagents, and product transportation.

The dewatering operation will provide a continuous flow of relatively constant quality raffinate sludge with a water content in the range of 70% to 75%. This water content is theoretically sufficient for producing both grout- and soil-like products. The only additional water required will be for daily machinery cleaning.

Waste to be delivered includes raffinate sludge, quarry soils, surface soils, sludge from the water treatment plants, and clay bottom. To minimize air emissions, quarry and surface soils delivered to the CSS material preparation area will be fed directly to the plant feed system and processed. The main plant operation is dependent upon relatively consistent moisture content limited to about 20% to prevent possible plugging of the separation screens. Very wet material, along with clay bottom, will be processed in the parallel plant which consists of a pug mill near the main CSS plant. The function of the parallel plant, is to delump and lower the moisture content of the processed waste by mixing in a sorbent, in this case fly ash. The

secondary function is to reprocess any soil-like mix from the CSS plant that may fail various test criteria. In this case, the mix will be loaded by front-end loader into the pug mill hopper, and ingredients will be added manually, as required, to generate an acceptable product.

The reagent delivery system must provide a continuous supply of cement and fly ash to the process.

The product in grout-like, soil-like, and possibly stabilized clay bottom will be discharged at three independent loading points. The processing will provide simultaneous loading of clay and either soil-like or grout-like product.

6.3.2.2.1 Materials for Processing. All materials selected for processing will be delivered to the vicinity of the CSS material preparation system. Materials in solid form such as quarry soils, surface soils, spoils pile soils, and clay bottom will be fed directly into the plant, when possible, to minimize intermediate storage and the potential exposure of the excavated material to the atmosphere and associated air emissions. Material in liquid form, such as raffinate sludge and possibly water treatment plant sludges, will be pumped from the dewatering facility into storage tanks at the CSS plant.

6.3.2.2.2 Reagents. Cement and fly ash are the major reagents used in the CSS treatment process. Portland cement is a commonly used CSS reagent. Selection of the specific type of Portland cement is a function of the sulfate content of the waste to be treated, the time required to develop strength, and the maximum tolerable heat of hydration. The raffinate sludge is known to contain relatively high levels of sulfate and requires relatively sulfate-tolerant cement, such as Portland Type II cement. Type V cement may be required to process sludge having a sulfate content exceeding 15% by weight. The elevated sulfate concentration also demands that the more sulfate-resistant ASTM Class F fly ash be used. The fly ash should allow 50 lb/sq in. strength to be obtained while producing a sulfate resistant product; however, batch testing will be required for confirmation.

6.3.2.2.3 Electric Power Supply. Electric power will be supplied from the nearest existing substation into the main electrical panel at the CSS plant. Power consumption is estimated to be in the range of 670 kW to 750 kW for the CSS production capacity of 100 tons/hr. This includes all equipment, lights for night operation, and operating support

systems. It is recommended that hydraulic systems and components be used where possible to reduce the consumption of electricity and maintenance costs.

6.3.2.2.4 Process Water. The CSS plant will use contaminated water from the dewatering facility or any other available contaminated water. The process water will be used to flush equipment such as mixers, discharge bins and material handling equipment, when the plant is not operating. The estimated daily consumption of washdown water is in the range of 800 gal to 1,000 gal. The light slurry consisting of the processed waste should be pumped into a separation tank. Separated solids can be processed in the parallel plant together with clay and sorbent. The washdown water can be reused.

6.3.2.2.5 Testing Requirements. Three testing procedures are required; there are presently no alternatives to these tests. Passage of the TCLP criteria is required for selected contaminants. Passage of the TCLP is based on the leaching of a desegregated sample with a particle diameter of less than 0.375 in. with an acetic acid solution for a period of 18 hours. The EPA specifies an unconfined compressive strength (UCS) of 50 psi as the minimum for a monolithic CSS-treated product (EPA OWSER Directive No. 9437.00-2A). However, the minimum UCS requirement for the soil-like product should not apply, since placement of the soil-like product will be controlled by compaction requirements. The soil-like compaction requirements should be established based on the stability requirements of the disposal facility. It is proposed that the CSS product be tested daily or about one test per 1,000 tons of product.

The treated grout-like product is subject to the 50psi UCS and paint filter test (EPA Method 9095-SW846) criteria. The paint filter criterion may not be appropriate, however, because water content must be kept high for the grout fluidity for filling debris voids in the waste cell.

Because of the turnaround time required for the tests discussed above, real-time surrogate testing (e.g., slump, unit weight, percent water) will be established for the CSS products. If the CSS products ever fail the surrogate tests, the CSS operation will stop production and the product will be reprocessed. The grout-like product will be repumped into the primary mixer by the pump used for product handling, and the necessary ingredients will be loaded and mixed. When the soil-like or stabilized clay bottom product fails the required tests, it will be reprocessed in the parallel plant. The ingredients will be manually added in the parallel plant. If failure of the grout-like product is detected in the disposal cell area, the truck will return to

the CSS plant and the grout-like product will be reprocessed in the parallel plant, regardless of product type, by converting it into a soil-like product by combining the mix with the clay. The ingredients will be fed manually.

CSS reagent quality certification will be required upon delivery to the plant by the vendor, with the Portland cement and fly ash composition and characteristics falling within industry-recognized tolerances. Plant metering devices will be tested and certified as recommended by the manufacturer.

6.3.2.2.6 Other Requirements.

A. Staffing requirements. It is estimated that the following staff will be required to operate the proposed CSS plant.

Employee Classification Description	Shift 1	Shift 2
Process engineer/plant manager is responsible for overall operations of the CSS facility.	1	-
Foreman is responsible for direction of the operational staff during the processing.	1	-
Assistant foreman/relief man reports to the foreman and has responsibilities similar to the foreman.	-	1
Health and safety technician	1	1
Control room operator reports to the plant manager.	1	1
Plant operators report to the foreman and are responsible for actual plant operation.	5	5
Laboratory technician is responsible for conducting TCLP, UCS, and paint filter tests. (Tests assumed to be performed in separate on-site laboratory.)	1	1
Maintenance - millwright, machine repairman, electrician, plumber, electronics specialist, and heavy equipment mechanic all report to the site maintenance foreman and will be assigned to the CSS facilities on a periodic, but continual basis.	3	3
Total	13	12

Site Staff Employees. The CSS plant operation described above will require an incremental increase in site supervisory, accounting, payroll, and human resources personnel. Additional time, perhaps 1 hr/d, will also be required of the site's safety personnel to perform routine safety inspections and to monitor employee work practices.

The drivers needed to transport waste from the stockpiles at the TSA to the facility, and CSS-treated product from the plant to the disposal cell are not included in this staffing estimate. It is vital that an adequate trucking fleet be available to continually remove treated waste from the plant to ensure that the facility is never temporarily shut down due to lack of trucking capacity.

- B. Worker protection. All labor activities will be performed in compliance with the site Health and Safety Program. The requirements of this program will be augmented, as necessary, to ensure compliance with all worker safety guidelines and regulations.

Personal protective equipment requirements. Employees directly involved with plant operation and maintenance will be required to wear Level C PPE over their company-provided work clothes. The company-provided attire includes hard hat, hearing protection, safety glasses, half-face and full-face respirators, Tyvek suit, neoprene gloves, and neoprene boots. Aluminum duct tape will secure the openings between the different garments. Because selected workers will be required to wear a respirator, all operators must be certified by a physician for respirator use. All employees will participate in a medical surveillance program. They will also be required to have completed a 40-hour OSHA-approved hazardous waste operations training class in compliance with 29 CFR 1910.120, 40 CFR 264.16, and 49 CFR 172.700. Supervisors will also be required to complete an OSHA-approved 8-hour supervisors advanced hazardous waste training class in compliance with 29 CFR 1910.120. Any required site-specific radiologic training classes will also be completed.

- C. Quality assurance/quality control. The operation of the conceptual CSS facility will comply with the site *Project Management Contractor Quality Assurance Program* (Ref. 6). This program will be augmented, as necessary, to document compliance with all regulatory and performance criteria.

- D. Office and change room requirements. The process engineer and the plant foreman will need office space. This space could be located in the main site administration building or, alternatively, in an office trailer. All workers will use the site's locker and shower facility and lunch room. Two complete change-outs of protective clothing will be required. The selected workers will don the required level of PPE

prior to commencing work each day. They will doff their PPE before eating lunch, and change back into protective clothing prior to recommencing work after lunch. The second change will occur at the completion of the employee's shift.

6.3.2.3 Plant Operations. The various components of the CSS plant operations are illustrated in Figure 6.3.2-1. They are:

- Material preparation.
- Component storage.
- Radon emission control.
- CSS plant feed system.
- Mixing system.
- Product discharge system.

The components of the CSS treatment facility were selected based on the results of MVE studies, related bench scale testing, and on-site laboratory testing results, along with vendor information and previous projects experience. The preferred alternative meets specified functional and performance criteria.

- Material preparation refers to the pretreatment of solid waste in the form of particle separation. Oversized particles will not be processed in the CSS plant. Dust control will be provided by dust suppression in areas of transfer points. Raffinate sludge preparation is part of a separate task. In the CSS plant, raffinate sludge preparation is combined with storage, and preparation is limited to continuous mixing to achieve a homogeneous consistency.
- Radon emission control systems are assumed to be located where the raffinate sludge is in a dynamic state because of mixing, pumping, or transport in the piping system. It is recommended that radon be removed at the point in the process where radon is found or allowed to generate to its highest concentrations.
- The CSS plant feed system supplies feed materials from the point of material preparation and component storage the primary mixing system. The purpose of the primary mixing feed system all components in the waste stream are added at the proper ratio, and an acceptable product is generated.

- The mixing system consists of two independent systems. The plant mixing system combines the waste components and the reagent and generates either of two basic products: grout-like or soil-like. The second independent mixing system in the parallel plant is designed to process clay only; the only product will be in a soil-like form.
- The product discharge system is separate from the other plant systems. Truck loading can be accomplished simultaneously for both product types produced in the main plant and the soil-like product produced in the parallel plant using clay.

Each of the major components associated with an operation is evaluated in the following subsections according to the procedure set forth in Sections 3.3 through 3.8 of the scoping document.

The CSS plant production time versus years of operation for various production capabilities is shown on Figure 6.3.2-2. The CSD reports that CSS processing will require approximately 23 months, including the winter shutdown period. The actual process time is 17 months (320 days), operating five day/week. The required plant capacity, based on Figure 6.3.2-2, is therefore 80 tons/hour, 14.5 hour/day.

The parallel plant capacity is based on 8 hour/day of daytime-only production. The production capacity is estimated to be the same as the CSS plant capacity at 80 tons/hour.

The total quantity of material to be processed at the CSS plant is approximately 298,000 tons. This will yield approximately 370,000 tons of treated product requiring disposal in the cell. The parallel plant will process approximately 77,000 tons of clay with fly ash and produce a soil-like product only. This plant will produce approximately 90,000 tons of treated product. Added to the product produced by the main CSS plant, an overall total of 461,316 tons of treated material will be produced. The material balance for the CSS process is depicted in Figure 6.3.2-3.

The production plant capacity is calculated based on the waste quantities and the desired products. The soil-like product consumes all available soil and part of the raffinate sludge. The remaining raffinate sludge is used in the production of a grout-like product.

6.3.2.3.1 Reagents. Reagents provide the necessary cohesion between waste particles and immobilize chemical ions. The reagents considered are:

- Portland Type II cement.
- Fly ash - ASTM Class F or C.

The only other stabilization processes acceptable to the U.S. Environmental Protection Agency (EPA) are proprietary. Therefore, value engineering and selection of alternatives were not performed. Proper selection of the CSS reagents is critical to the generation of an acceptable product. The proposed Oak Ridge formula of 60% ASTM Class F fly ash and 40% Type II Portland cement, mixed at a 0.6 to 1 reagent-to-waste blend (Ref. 31), apparently overdoses the Weldon Spring wastes with binder. Waste technology group bench testing used a 0.4 to 1 ratio to produce the OP-II-1 monolithic product using raffinate sludge (Ref. 32). This product sample demonstrated adequate strength and passed the toxicity characteristic leaching procedure (TCLP) test. The same ratio was used to produce the OP-III-6 soil-like product using raffinate sludge, soil, and binder in the ratio 1 plus 1 plus 0.2. This product also passed the TCLP test and demonstrated adequate strength to ensure disposal cell stability.

The conceptual CSS plant design offers sufficient flexibility to allow for substantial changes in reagent and waste blend recipes. On-site additional testing will determine the exact ratio of waste and binder and the corresponding moisture content required to optimize the CSS grout and soil-like mixes.

6.3.2.3.2 Material Preparation. Material preparation includes material separation, handling, and storing and consists of the following processes:

- Material segregation and delumping.
- Material screening.
- Oversized material washing.
- Material handling.
- Material storing.

The results of an MVE session on material segregation, delumping, and screening are summarized in MVE Table 6.3.2-1 through 6.3.2-3. The equipment evaluated includes the following:

- Vibrating grizzly.
- Vibrating screens.
- Rotating washing trommel.

These pieces of equipment were considered superior due to their ease of maintenance and operation and their ability to process a given material.

The vibrating grizzly has a number of bars designed to delump the materials dumped onto the equipment. The inlet hopper directs the material into the upper portion of the grizzly where dust control is provided by a dust suppression system. The process area is enclosed and sealed to prevent dusting.

The vibrating screen is a conventional flat-screen-type design adapted for waste processing. Dusting is controlled by a sealed cover. The vibrating screen operates in series with the vibrating grizzly.

The rotating trommel consists of a horizontal metal cylinder with a screen-equipped discharge point. The equipment slowly rotates the material, separating larger particles and discharging them on the opposite side. Small particles are screened and collected in the hopper.

The design of the material preparation system is based on material from the TSA and the raffinate pits. Quarry soils from the TSA or surface soils will be preferably loaded directly onto the vibrating grizzly to avoid reloading, reducing possible radon exposure. The material moisture content must be monitored to ensure that it does not exceed 20% to prevent plugging the separation system. Oversized material, consisting of rocks or lumps of soil, will be discharged into the washing circuit. Dusting in the loading hopper of the vibrating grizzly will be controlled by using spray bars to provide dust-free processing with good accessibility for maintenance. As noted above, monitoring the moisture content of soils is important to prevent the plugging of vibrating screens and to ensure transfer into the washing circuit. It is recommended that a roofed structure be provided above the grizzly loading hopper to prevent rain from affecting the processing and to provide additional dust filtering, if needed.

The process separates plus-2-in. material consisting of rocks or lumps from the vibrating grizzly and vibrating screen and transports it into the oversized material washing equipment. The equipment alternatives for oversized material washing are:

- Rotating washing trommel.
- Wet vibrating screen.

The results of the MVE session are shown in MVE Table 6.3.2-4 through 6.3.2-6. The preferred alternative is a rotating trommel, based on the criteria outlined in the MVE session. The most significant advantage of the rotating wet trommel is its ability to handle a broad range of material sizes. The material washing will separate minus-2-in. material for CSS processing from the oversized material designated for placement in the disposal cell. This wet processing system uses contaminated water from the dewatering facility. The dirty water will be used in the CSS plant. Minus-2-in. material, consisting mostly of soils and some rock, will be conveyed to the covered pile area for necessary storage.

The equipment alternatives for conveying the separated materials are:

- Enclosed belt conveyor.
- Screw conveyor.
- Screw lift.
- Bucket elevator.

MVE Table 6.3.2-7 through 6.3.2-9 summarizes the results of the MVE session on conveyance equipment. The preferred alternative is a covered belt conveyor for horizontal or inclined conveying and a bucket elevator for vertical transportation.

The covered belt conveyor is designed to protect the material being conveyed from the weather and to reduce dusting. This conveyor is used for horizontal or inclined operations. The bucket elevator also protects the material being conveyed and is designed for vertical operations only. Both conveyors are easy to operate.

The screw lift conveyor combines horizontal and vertical screw conveyors into one system. The use of this system, however, is limited to conveying uniform particle sizes and relatively dry materials.

The storage pile provides surge capacity for the operation as previously discussed. The pile is assumed to store about 500 tons of material to provide a reserve for processing. The

roofed enclosure is recommended to protect the stockpile from rain and to control radon emissions if necessary. The storage facility should include dust suppression measures.

Raffinate sludge preparation involves mixing in vertical bins with conical bottoms. This pumpable substance is mixed by pumps providing continuous circulation. The equipment alternatives are:

- High-speed centrifugal pump.
- Progressive cavity pump.
- Gear pump.

These alternatives were evaluated in an MVE session, the results of which are presented in MVE Table 6.3.2-10 through 6.3.2-12. The preferred alternative is a high-speed centrifugal pump. This equipment has an advantage in that it vigorously stirs the raffinate sludge, which separates radon from the sludge. This separation is needed to minimize radon evolution during the next mixing process, where the time schedule for mixing and related operations is critical.

A second reason for intensive mixing is to mitigate the potential influence of the flocculent, which may stiffen the sludge on further CSS processing. Vertical bins with conical bottom are considered the only practical method of storing raffinate sludge for gravity loading. Flat-bottomed tanks are impractical for this application.

6.3.2.3.3 Radon Emission Control. Radon emanation tests conducted on site have provided evidence of radon emission when raffinate sludge is in motion. Disturbing the sludge during the CSS processing will conceivably cause significant radon emissions. Depending on future test results, radon emission controls may be required during the processing steps where the raffinate sludge is agitated intensely or for prolonged periods of time.

To control radon emissions, the following radon control devices were considered:

- Carbon absorber.
- Molecular sieve.

These alternatives were evaluated in a MVE session, the results of which are summarized in MVE Table 6.3.2-13 through 6.3.2-15. The preferred alternative is a carbon absorber, based

on the criteria outlined in the MVE session. The molecular sieve requires high pressure to function properly. The carbon absorber is a proven technology for the adsorption of decaying radon daughters.

The radon removal system is composed of two independent circuits: a primary pressurized circuit and a secondary pressurized adsorption/decay circuit.

The primary circuit comprises a gas compressor, a compressed air storage tank, a chemical air dryer, and a primary carbon absorber. The primary circuit pressurizes and dries the headspace gas from the raffinate sludge storage tanks, and then directs this gas through the carbon adsorbent under pressure (nominally 50 psi) at a very slow linear velocity, thereby removing any contained radon. The gas then expands back to atmospheric pressure and is returned to the storage tank. This primary circuit operates continually, removing radon from the storage tank headspace gas.

The secondary circuit consists of a chemical air dryer and two independent high-pressure stationary adsorption columns. The secondary circuit treats the volume of storage tank headspace gas that exceeds the capacity of the primary circuit. When raffinate sludge is added to the storage tank at a rate greater than it is transferred from the storage tank, the headspace gas pressure increases. This increase in pressure is undesirable. To eliminate pressure, the excess gas volume is exhaled from the storage tank, pressurized, and directed to the secondary circuit. The excess volume of air is withdrawn from the tank, compressed, and directed through the secondary circuit's air dryer to one of the two stationary pressurized carbon absorber columns. All excess air will be transferred to this stationary absorber column in this manner until the pressure in this carbon absorber is equal to the system operating pressure (nominally 50 psi). When that pressure is reached, additional excess air will be directed into the second absorber. The contained air will be held in the pressurized absorber columns in a static condition for a time sufficient to allow radon to decay into solid daughter products (approximately two average lives or 11 days). After that period, the air in that particular absorber column will be released into the atmosphere, and that column will again be available to repeat the cycle, as necessary.

There is limited data and information on the radon levels in the raffinate sludge, quarry soils, surface soils, and clay bottom. It appears logical to remove radon when the raffinate sludge is in a dynamic state, possibly after dredging, by intensive additional agitation of the

sludge before processing. This operation is highly recommended for trial in a pilot-plant testing program.

6.3.2.3.4 Reagent Storage and Feed System. The reagent component storage system shall provide a five day supply of cement and fly ash. Five days' storage is considered sufficient to handle minor shipping disruptions from the supplier, but cannot accommodate longer interruptions. Storage is assumed to be in vertical bins equipped with conical bottoms. Delivery of reagents into the storage system will be via conventional transport vehicles, off-loaded pneumatically to minimize air emissions. The top of each bin will also be equipped with a vent filter to control dust. Material will be transferred pneumatically from the storage bins to the CSS plant feed hoppers. This system offers the possibility of premixing cement and fly ash in a dry form at the proper ratio prior to transport to the CSS feed hoppers. Bolted, prefabricated segment bin construction is recommended to allow future reuse, since the cement and fly ash are not contaminated. The advantage of this construction is a self-supported bin erected on a concrete ring.

The plant feed system will provide continuous feed into the mixing system. It must have variable capacity to allow rapid transition from a grout- to a soil-like product or vice versa. Three types of feed systems are available:

- Mechanical feed system (screw conveyor).
- Pneumactical feed system (pneumatic).
- A combination of mechanical and pneumatic systems.

These alternatives were evaluated in an MVE session summarized in MVE Table 6.3.2-16 through 6.3.2-18. The combination system is the preferred alternative because of its capability to satisfy the plant needs, and to efficiently perform this function.

A screw conveyor and pneumatic feeder are the components of the selected system. A screw conveyor with hydraulic drive is preferred for solid feed material, such as quarry soil and surface soils, for dependable material handling. The advantage of hydraulic drive is its capability to vary the mix dosing.

Pneumatic feeding is recommended for cement and fly ash to provide dependable material handling with the possibility of changing the feed rate. It is assumed that fly ash feed, required

for the parallel plant clay processing, will be supplied by the pneumatic feed system installed at the same feed bin as the main CSS plant.

6.3.2.3.5 Mixing System. The types of mixing equipment considered feasible for CSS operation include:

- High-shear mixer.
- Pug mill.
- Ribbon mixer.
- Homogenizer.

Other types of mixing equipment are also available; however, this equipment is not listed because it is not considered practical for CSS operation, from the standpoint of capacity or material discharge.

The above-listed alternatives were evaluated in an MVE session summarized on MVE Table 6.3.2-19 through 6.3.2-21. The preferred alternative is the combination of the high-shear mixer in series with the pug mill. There is no superior advantage of the high-shear mixer over the pug mill. Both have a specific mission in the processing.

A high-shear mixer is needed first to vigorously mix all components, as it has the advantage of batch-mode mixing, which allows radon removal from small head space above the mix. The intensive mixing is preferred, because it is necessary to quickly moisturize all the dry components with the wet raffinate sludge. Results from waste technology group bench-scale studies indicate that premixing can shorten the mixing time.

Next in the series is the pug mill. Its main advantage is that it can operate at variable speeds, allowing processing at an optimal rpm relative to the mixing time or other mixing requirements. A second advantage is the possibility of installing two separate, independent discharge gates for the grout- and soil-like product.

A pug mill is also recommended for the parallel plant where mixing is the only operation. The pug mill is selected because it can process the failed batches produced at the CSS plant, when the variability of mixing time will be a major advantage. The regular duty of this pug mill will be process to the high-moisture clay bottom, and to thoroughly mix the clay with a sorbent.

In this case, the sorbent will be the fly ash. Vigorous mixing is not required; the primary mixing functions are delumping and moisture control.

6.3.2.3.6 Product Discharge. A separate product discharge system will be provided for each of the three CSS products produced at the main CSS plant and the parallel plant. This is driven by the necessity of the two-plant concept, and the need to separate the soil-like and grout-like products discharged from the main CSS plant for placement in the disposal cell. No alternatives were evaluated. The discharge point for both products at the three separate locations is above the center of the delivery trucks. Each discharge point will have equally sized bins with conical bottoms supported by structural steel.

The grout-like product will be discharged from the pug mill into a pump sump and then pumped into the plant loading bin. Truck loading by gravity is assumed. This system is also proposed for collecting flushing water from daily cleaning. The water with some solids will be pumped into a separation unit where solids will be discharged for further processing in the parallel plant. Separated water will be reused for the next cleaning.

The soil-like product will be elevated by conveyor directly from the discharge gate of the pug mill into the product loading bin. Truck loading will also be by gravity.

The soil-like product from the parallel plant will be elevated by conveyor into the product loading bin and gravity discharged into delivery trucks.

The product loading bins for all three systems will be sized for the same retention time and will hold no more than a 30-minutes production supply.

6.3.2.4 Operational Uncertainties. Although a facility and treatment process may be extensively tested, unforeseen difficulties may arise during full-scale operations. Some uncertainties, however, are predictable, and addressing these potential problems during the pilot-plant testing is recommended. Specific difficulties may include:

- Raffinate pumpability.
- Radon removal.

- Mixing.
- Additional waste processing.
- Raffinate sludge pumpability is only assumed at this time. The estimated water content of 70% to 75% is based on engineering judgment. The presence of a flocculent can decrease the raffinate pumpability, as was observed in the on-site bench-scale testing. The selection of the proper flocculent is crucial and is discussed further in Sections 5.3.5 and 6.3.5.
- Radon removal technology is available in the form of adsorption on a carbon bed where the captured radon decays to Pb-220, which attaches to the carbon for about 22 years, when the Pb-220 also decays. It is obvious that used carbon must be disposed of in the disposal cell. The uncertainty lies in the best location for the radon removal system. During on-site bench testing, it was found that disturbing the raffinate sludge created radon emissions. Disturbing the sludge begins with the dredging and continues through flocculent mixing dewatering, and raffinate pumping into the CSS plant storage tanks. There appears to be a need to locate another radon removal system, similar to that in the feed bins, at the primary mixer, and possibly at the product discharge areas.

Radon removal at the most intensive radon evolution points in the CSS process should be evaluated as part of the CSS pilot plant program.

Mixing is a very sensitive operation where the sequence of charging ingredients and mixing time can play an important role in the quality of the product and in the uniformity of the mix. The size of the batch, in relation to the size of the mixer and the rpm of the mixing, is also a very important issue. None of these items have been tested using the raffinate sludge or related Weldon Spring waste. It is recommended that these uncertainties be investigated during the pilot-plant testing program.

Materials other than those listed in the Section 5.3.1.1 may require stabilization. Ash pond and Frog pond, both located in the northern part of the plant, contain soil and sediment contaminated by the former trinitrotoluene (TNT) and uranium enrichment plant. Other areas of the former plant also contain elevated concentrations of contaminants in the soils that may

require treatment by the CSS process. Additional soil characterization on site will define areas and quantities of contaminated soil to be treated.

Certain containerized chemicals and materials currently in storage in Building 434 may be amenable to CSS processing. These materials have not been fully characterized and the volume for processing is not defined.

Bench testing should be provided to determine the necessity for further solidification of the above mentioned areas, and to include the results in the pilot testing program.

6.3.3 Vitrification Process

The objectives of vitrification are: (1) to stabilize the chemical constituents to minimize their negative impact on the environment, and (2) to physically stabilize the raffinate sludge to allow its placement into a disposal cell. Evaluations of these materials indicate that they can be successfully vitrified. To treat the raffinate sludge, clay bottom, and quarry soils, the vitrification treatment plant requires integration of the following circuits: physical preparation (raffinate and soil/clay), waste blending and storage, melter feed, melter, product discharge, and off-gas treatment. The operational activities associated with these circuits are described along with those associated with melting additives, waste mixtures, and radon emissions control circuits, which may be required.

The conceptual design presented in Section 5.3.3 is based on the evaluation of alternatives for the above operational activities. The evaluation of alternatives followed the approach described in Section 3. These evaluations considered many requirements or criteria such as the capability of the systems to handle various operational uncertainties, product quality criteria, environmental impacts, ability to implement the system, minimization of residual waste, operational histories, and worker safety.

This approach emphasized the use of MVE sessions to identify and evaluate various alternatives for the different design components in a consistent and well documented manner. The following sections present operational and functional aspects of the vitrification facility that were evaluated.

6.3.3.1 General. The conceptual vitrification facility is similar to a medium-size glass plant, coupled with a small mineral processing mill that has been enclosed to prevent the escape of fugitive dusts and vapors.

The mineral processing portion of the facility consists of feed preparation equipment (screens, conveyances, dryers, and mills) and waste blending and storage equipment (pneumatic transfer, static mixers, and silos). The glass plant portion consists of melter feed equipment (pneumatic transfer and bins), melters, product discharge equipment (quench tank, conveyor, and bins), and off-gas treatment equipment (particulate, acid-gas, submicron aerosol, temperature, and high-efficiency particulate air (HEPA) control devices). The mineral processing portion of the facility accepts the dewatered raffinate, clay bottom material, and quarry soils, reduces particle size to minus 1 mm (nominal), dries the wastes to approximately 99% solids, and stores the final products for melting in quantities large enough to ensure that the melters can operate relatively uninterrupted 24 hours/day for 365 days/year.

The melter accepts the pretreated waste after it has been blended in a ratio that will ensure the proper composition for the required vitrified product, melts that material, delivers it to a water-quench or "fritting" tank where it is rapidly cooled or frozen into a vitreous fritted product, and lifted from the tank to a product bin to await truck transport to the disposal facility. Similar to glass industry melters, the melters in the vitrification facility are planned to operate essentially 365 days/year, except for planned maintenance periods (< 10%). Continual operation is advantageous, because it reduces downtime due to melter refractory fatigue related to frequent thermal shock; continual operation also maximizes capital investment in the equipment.

The melter off-gas containing particulates (including radionuclides), acid-gases (SO_x and NO_x), and submicron aerosols (including volatile metals and metalloids), is directed to the off-gas treatment circuits, which remove, destroy, or otherwise alter the off-gas to allow its release to the atmosphere with strict adherence to regulatory requirements. The vitrified waste form is essentially inert in the environment and placement in the disposal cell will provide added protection. The vitrified product will have physical characteristics similar to a sandy soil allowing its placement in the disposal cell with common earth-working equipment.

6.3.3.2 Operational Requirements. Operation of the vitrification facility is dependent upon coordination among the dredging and dewatering operations for delivery of raffinate sludge, excavation and delivery of clay bottom material, delivery of quarry soils,

delivery of additives, if they are later determined to be necessary, delivery of natural gas, and water treatment plant operations, product transportation to the cell, and product placement in the cell.

6.3.3.2.1 Waste Materials for Processing. All waste materials for processing will be delivered to the appropriate physical treatment circuits. The physical pretreatment circuits are planned to operate two shifts per day, five days/week, 52 weeks/year, except during planned maintenance shutdowns. Raffinate will be transferred from the dewatering facility at 80% solids via a chain conveyor to the raffinate pretreatment circuit, therefore an adequate supply of dewatered raffinate must be made available at the dewatering facility. Storage has been incorporated into the pretreatment circuit design to allow for unexpected excavation or dewatering downtime lasting up to one week, without causing the melters to run out of feed material. Soils or clay bottom material will be delivered to the soil/clay preparation circuit. Soil or clay only will be accepted at any one time because the two materials will be processed through the same circuit, with some operational modification required for clay. This approach matches the planned excavation of these materials: clay will be processed when it is available and quarry soils stockpiled at the TSA will be processed when clay is not available.

6.3.3.2.2 Additives. The current design does not include the need for melter additives. However, it is likely that the addition of small quantities of some simple additives (waste glass) or fluxes (crushed lime) may be advantageous because possible reduction of melting temperature, and therefore, reduction in consumption of natural gas. This concept is further discussed in Sections 5.3.3.4.3 and 6.3.3.3.2. If such additives are used, it is likely they will be added to the process via the raffinate preparation circuit.

6.3.3.2.3 Natural Gas Supply. An estimated 4.5×10^6 Btu are required to melt 1 ton of soil/waste. At the average throughput of 125 tons/d and assuming 10^3 /day. Btu/ft³ of natural gas, approximately 562,500 ft³/day of natural gas would be required. Similarly, a maximum of 810,000 ft³ is estimated to be required if operating at 180 tons/day. Discussions with Laclede Gas Company indicate that this amount of gas easily could be made available and would only require the construction of a new gas main from the main road to the site. An EPA Superfund Innovative Technology Evaluation report, however, (Ref. 117) contains results of a cycloic melter demonstration having an energy consumption of 30.3×10^6 Btu/ton using natural gas.

6.3.3.2.4 Water Treatment. It is estimated that all water removed from the wastes during drying in the preparation circuits will require treatment at the site water treatment plant (SWTP) prior to off-site discharge. Further testing of thermal drying, will be necessary to determine the quality of the water condensed from drying operations. Depending upon the stage of the dredging operations, some of this water may require recycling to the raffinate pits to help float the dredge. It is estimated that approximately 5.2 gal/minute would be produced by the drying operations. This small amount of water might be used with little or no treatment in other circuits in the vitrification facility, such as the off-gas treatment circuits or the product discharge quench tank. Other possibilities would be to install a small WTP at the vitrification facility or use a portable WTP.

6.3.3.2.5 Testing Requirements. The alternatives for vitrified product testing requirements during operations include (1) proving as part of pilot scale and full scale plant startup that the vitrification process adequately destroys or immobilizes the constituents of concern before its implementation, (2) developing surrogate testing procedures that allow rapid turnaround time and do not delay the placement of the product, provided it passed the surrogate test; and (3) sampling and testing the product in regular batches, and waiting for TCLP test results before placing the product into the disposal cell. The selected alternative is to prove the process prior to its implementation by establishing quality control parameters and associated parameter values. The advantages of this approach are that the product does not require storage, and treatment is not delayed by waiting for the relative lengthy TCLP turnaround. If a rapid surrogate test can be identified, the surrogate testing alternative would be very attractive; unfortunately, a surrogate test has not yet been identified.

Using data collected through bench, engineering, and pilot-scale studies to document that the process produces an acceptable vitrified product is operationally advantageous due to the relatively long turnaround time required for TCLP analysis. The vitrified product from each shift could be stored temporarily until samples collected were shown to pass the TCLP criteria. This alternative would require the storage of a shift's production (nominally 47 tons/shift) for approximately 32 hours or four shifts. Such storage would require four or five bins of approximately 47 tons (about 36 cu yd) capacity each. The product could be conveyed to each bin rather than to the truck loading bin, as shown in the conceptual design; this would not inconvenience operations or significantly increase the capital and operating expenses of the treatment process.

6.3.3.2.6 Product Disposal. Waste placement is scheduled to occur during one shift per day, 5 days/week, while the vitrification facility is scheduled to operate around the clock, 7 days/week. This difference in operational time frames requires that the vitrified product be stored for two shifts, at a minimum, and for two days during weekends. Vitrified material does not require special storage or handling and therefore the product could stay in storage indefinitely. Section 6.2.5.3.2 discusses waste placement activities.

6.3.3.2.7 Other Requirements.

A. Staffing requirements. It is estimated that the following staff will be required to operate the proposed vitrification facility.

Employee Classification Description	Shift 1	Shift 2	Shift 3
Process engineer/plant manager responsible for overall operations of the vitrification facility.	1	-	-
Foreman responsible for direction of the operational staff during processing.	1	1	1
Assistant foreman/relief men who reports to the foreman and has similar responsibilities as the foreman.	1	1	-
Control room operator who reports to the plant manager.	1	1	1
Plant operators who report to the foreman and are responsible for actual plant operation.	6	6	3
Laboratory technician responsible for conducting TCLP tests. (Tests assumed to be performed in separate on-site laboratory.)	1	-	-
Maintenance - millwright/welder repairman, machine repairman, electrician, plumber, electronics specialist and heavy equipment mechanic who report to the site maintenance foreman and will be assigned to the vitrification facilities on a periodic, but continual basis.	3	1	1
Total	14	10	6

B. Worker protection. All labor activities will be performed in compliance with the site health and safety program. The requirements of this program will be augmented, as necessary, to ensure compliance with all worker safety guidelines and regulations. Employees directly involved with plant operation and maintenance will be required to wear Level C personal protective equipment (PPE) over their company provided work clothes. Level C PPE will include hard hat, hearing protection, safety glasses, half-face respirator, Tyvek suit, neoprene gloves, and neoprene boots. Aluminum duct tape will seal the openings between the different garments. Because selected

workers will be required to wear a respirator, all operators must be certified for respirator use by a physician. All employees will participate in a medical surveillance program. They will also be required to have completed a 40-hour OSHA-approved hazardous waste operations training class in compliance with 29 CFR 1910.120. Supervisors will also be required to have completed an OSHA eight-hour supervisors advanced hazardous waste training class in compliance with 29 CFR 1910.120. Any required site-specific radiologic training classes will also be completed. Working in a relatively high level of personal protection will impact employee productivity.

- C. Quality assurance/quality control. The operation of the conceptual vitrification facility will comply with the site Quality Assurance/Quality Control Program as described in the *Project Management Contractor Quality Assurance Program* (Ref. 6). This program will be augmented, as necessary, to document compliance with all regulatory and performance criteria.
- D. Site staff employees. The staffing requirements for vitrification facility operation described above will necessitate an incremental number of additional site supervisory, accounting, payroll, and human resources personnel. An incremental amount of time, perhaps 1 hour/day, of the site's safety personnel will also be required to perform routine safety inspections of the vitrification facility and of the employees' work practices. Additionally, the drivers needed to transport waste to the facility, to the stockpiles at the TSA, and to transport vitrified product from the facility to the disposal cell are not included in this staffing estimate.
- E. Office and change room requirements. The process engineer and the plant foreman will need office space. This space could be located in the main site administration building or, alternatively, in an office trailer. All workers will use the site's locker and shower facility and lunch room. Two complete change-outs of protective clothing are anticipated. The workers will don their PPE as described above prior to commencing work each day. They will doff their PPE prior to eating lunch, and change back into protective clothing prior to recommencing work after lunch.

6.3.3.3 Plant Operations. The operation of the vitrification facility encompasses a number of integrated treatment circuits: waste material acceptance, delivery, and preparation

circuits; waste storage and blending circuits; melter feed circuits; melter circuits; product discharge circuit; and off-gas treatment circuits. Figure 5.3.3-2 shows the relationship among these circuits. The facility is designed to meet the functional and performance requirements listed in Section 5.3.3.2 and easily process the site wastes in approximately four years; the treatment rate of the facility could theoretically be increased to accommodate the processing of the wastes in approximately 2.75 year by simple modifications to its operation; no significant mechanical modifications would be required. Operational requirements to reduce treatment time would involve more shifts per day and/or more days per week to operate the material pretreatment circuits, thus increasing the waste material, fuel, and air feed rates to the melters; corresponding increases in the electrical needs, water output to the water treatment plant and total annual and short-term emission releases would also occur.

The circuits described in this section were selected by evaluating the alternatives described in Sections 3.3 through 3.8. These alternatives and their respective advantages and disadvantages are discussed and provided in tabular form in the following subsections.

6.3.3.3.1 Melter Circuits. An MVE session was held to evaluate the melter technology that would be used in the conceptual design for the vitrification of selected WSSRAP wastes. Evaluation and selection of melter technology is central to the design of the vitrification facility because it potentially impacts other major portions of the facility, particularly the off-gas treatment system for the melters, and to a lesser extent, the physical pretreatment circuits for the waste. Evaluation criteria were determined and then used to formulate melter alternatives, which were ranked according to their applicability to the WSSRAP. Fossil-fuel heated ceramic melter (FFHCM) technology was selected as the optimal melter technology for the site conceptual design, followed closely by plasma arc torch (PAT) technology. Joule-heated ceramic melters (JHCM) technology was a distant third. These three technologies were determined to be capable of treating selected site wastes. This section of the TID summarizes the MVE session, and then provides an overview of each of the three vitrification technologies deemed potentially applicable to the WSSRAP. Tabular summaries of the MVE, quality assurance (QA), and data needs evaluations are presented in Tables 6.3.3-1, 6.3.3-2, and 6.3.3-3, respectively.

The following criteria were used to evaluate the selected technologies:

- The product must pass the TCLP test.
- The technology must be capable of treating raffinate sludge, clay bottom material, quarry soils, and containerized wastes.
- The technology must be able to meet the target throughput rate of 125 tons of pretreated waste per day.
- Technologies using fossil fuels for energy sources would use natural gas.
- Technology must be commercially available.

Melter technologies formulated and evaluated were:

- Fossil fuel-heated ceramic melters (FFHCM)
- Inductively heated pot melters (IHPM)
- Joule-heated ceramic melters (JHCM)
- Plasma arc torch devices (PAT)
- Slagging incinerators (SI)

Criteria were developed to evaluate the above technologies. The criteria considered during this development phase of the MVE session were ranked, in order of relative importance:

- The minimization of residual waste.
- The relative state of development of the technology.
- The impact of a system failure.
- Additional treatment requirements.
- Flexibility in accepting feed with varying chemistry.
- Requirements for physical pretreatment of waste prior to melting.
- The mechanical availability of the melter.
- Maintainability.
- Relative product quality.
- Ease of operation.

- Energy conservation.
- Ability to accept other wastes.

These criteria were compared to each other and, using a numerical system, weighted in order of importance. The first seven criteria listed above (major criteria) were used to evaluate the alternative melter technologies. The last five criteria listed (minor criteria) were numerically ranked much lower than the others, and were not used in the initial alternative evaluations, but were considered during the incremental advantages/disadvantages evaluation.

Each melter alternative was scored using the above major criteria. The final ranking in order of preference is PAT, FFHCM, JHCM, IHPM, and SI.

The PAT technology ranked first followed closely by FFHCM. Note that by score alone, the inductively heated pot melter (IHPM) technology ranked higher than the JHCM technology, but the relative difference was less than 5%, which is probably within the error range of the MVE method. After a final evaluation of the numerical results, and considering the minor criteria, the JHCM technology was determined to rank above the IHPM technology. Considering which technologies were commercially available at scales that could treat site wastes and consistently produce a desirable product, the PAT, FFHCM, and JHCM technologies remained as contenders. The JHCM technology was ranked a distant third because of the potential for creating a soluble immiscible sulfate phase, which could contain enrichments of contaminants of concern, and the need for a very consistent and well characterized feed to satisfy melter operational requirements.

PAT technology has some minor technical advantage over FFHCM technology: ability to accept less extensively pretreated feed materials, slightly better acceptance of other waste materials, and conceptually smaller volume of off-gas requiring treatment. Both the PAT and the FFHCM technologies were capable of vitrifying site wastes; however, when cost was considered, FFHCM easily became the technology of choice. Each of the vitrification melter technologies is described in the Phase I Engineering Analysis of Remedial Action Alternatives (Ref. 48 and Ref. 49). Cost estimates from the *Phase I Engineering Analysis of Remedial Action Alternatives* indicate treatment costs for site wastes to be approximately \$100,000,000 for PAT (and JHCM), and \$65,000,000 for FFHCM. The MVE session, therefore, recommended that FFHCM vitrification technology be chosen for CDR design efforts.

6.3.3.3.2 Additives and Waste Mixtures. The alternatives evaluated for modifying the chemistry of the waste forms to make them amenable to vitrification included the use of no additives and waste blending and the use of standard glass-forming reagents. The criteria used for the evaluation along with other information is given in MVE Tables 6.3.3-4, 6.3.3-5, and 6.3.3-6. The alternative selected for this design is the blending of waste materials without the use of glass-forming additives. The advantages of this alternative include the minimization of final waste tonnage and volume; lack of requirements for additive delivery, storage, handling, and blending; that it does not exacerbate the formation of an immiscible sulfate phase with the related potential for product failure of the TCLP and corresponding additional treatment requirements for this phase should it occur; and lower cost.

Preliminary bench-scale vitrification testing of site wastes has been conducted (Ref. 33, Ref. 34, and Ref. 80). The results from these tests indicate that site soils will melt at approximately 1400°C and form a vitrified product, but that soil/clay must be added to the raffinate sludge to produce a desirable vitrified product. The addition of soil to the raffinate is necessary, because the raffinate is silica deficient, and the soil/clay at the site is silica rich and must also be treated. Therefore, it is advantageous to mix soil/clay and raffinate to facilitate treatment of the raffinate instead of simply adding silica from clean sand or waste glass. A wide range of raffinate and soil mixtures were tested, and the results indicate that as little as 30% (dry weight) soil is needed to vitrify the raffinate and produce an acceptable product that passes the TCLP as previously shown on Table 5.3.3-1. It is unlikely that such a high raffinate loading would be necessary, as soil and clay exist at approximately twice the weight (dry) of raffinate at the site and all of this material is slated for treatment.

It is also advantageous to mix the raffinate and soil for energy consumption and processing concerns: the blended material melts at a lower temperature than soil alone and has a lower viscosity. The melting temperature and viscosity are functions of the actual blending ratio. A 50:50 blend melts at approximately 1250°C and has a viscosity of approximately 900 poise. At 1475°C the viscosity drops to approximately 200 poise (Ref. 34). Those melting conditions are tolerated by available fossil-fuel-fired ceramic melter (and plasma arc torch melter) equipment designs. Other melting data including viscosity changes with composition has been generated during testing by Duratek/Vitreous State Laboratory-Catholic University of America (Ref. 33 and Ref. 80), but as yet, has not been reported in detail; more detailed bench-scale testing must be conducted to evaluate the variability of melting parameters due to variable blending ratios and waste compositions.

While it is assumed that the raffinate will be blended at a 50:50 ratio with soil or clay and that soil or clay may have to be melted alone when raffinate is unavailable, it may be beneficial to add some simple flux such as limestone to the soil/clay to reduce its melting temperature and viscosity for operational purposes, such as increasing melter life and decreasing melting temperature, and therefore, energy consumption. In all likelihood, raffinate would be used as sparingly as possible. It is likely that soils or clay bottom material will exist at the end of the treatment campaign without raffinate available as a flux, and other materials such as crushed limestone will be needed.

Melter technologies, such as JHCM, which rely on electrical conductive heating to achieve melting of waste materials have more stringent feed chemistry requirements than FFHCM technology, or PAT melters. The electrical conductivity of a melt must be within a relatively narrow range for a JHCM system to operate effectively (Ref. 33, Ref. 34, Ref. 80, Ref. 118, Ref. 119, and Ref. 120). In order to accommodate this range, melt modifiers are typically added to the waste feed. These modifiers are typically combinations of Na_2O and B_2O_3 at a total additive amount of 10% (dry weight.) or greater.

Bench-scale testing of the site 50:50 and other raffinate to soil/clay blends, with the required additives for the use of JHCM technology indicate that an undesirable immiscible sodium sulfate phase forms during melting (Ref. 33, Ref. 34, and Ref. 80). The formation of this phase is undesirable for a number of reasons. Most importantly, this phase isn't inert, is readily soluble, and therefore not likely to pass leach test criteria, including the TCLP, as many Resource Conservation Recovery Act (RCRA) constituents of the waste are unfavorably partitioned into the sulfate phase (Ref. 33 and Ref. 80).

Further bench-scale testing is required to adequately assess the correct waste blending required for vitrification of site wastes. Such bench-scale testing includes further characterization of the waste materials as to their chemical properties. Although a large amount of information exists regarding the composition of trace constituents in the waste materials, little is known about the bulk chemistry of these wastes. After further characterization of the site wastes, two types of crucible melt tests are recommended to further prove the robustness of the proposed vitrification process: end-member melt tests and bulk melt tests. End-member crucible melt tests should be designed and conducted to show that the blend of waste materials chosen for vitrification treatment of site wastes is robust enough, given the known variability in

the chemical constituents of the wastes, to consistently and predictively produce a vitrified waste form having acceptable process and product characteristics.

Previous work by both Pacific Northwest Laboratory (PNL) and Vitreous State Laboratories (VSL) has shown that a number of site waste blends appear to produce acceptable waste forms. The relative amounts of site soil and clay solids to raffinate sludge solids are currently estimated to be approximately 2:1. The raffinate is currently believed to contain more of the flux type of constituents and RCRA metals, and due to the advantage of adding this material to the soil/clay material to reduce melting temperatures of the soil/clay (and therefore energy, off-gas treatment, and other costs), that the raffinate to soil/clay blend ratio would ideally fall between 50:50 and 35:65. Efforts should be directed at preparing end-member blend compositions which reflect both the extremes in RCRA metals and arsenic, major element chemistry, and other constituents of concern for melting (SO_4 , F, NO_3). These waste blends should then be melted in crucibles and subjected to tests such as the TCLP and the Product Consistency test (PCT) tests. Evaluation of results of these tests will determine the robustness of the mixtures, and the process in general. During and after melting of the blends, other information such as melt temperature, melt viscosity, the development of immiscible phases, degree of devitrification, and mineralogic form of the product should be collected. This information will be used to assist in the design and operation of a vitrification facility.

Bulk melt crucible tests should be designed and conducted to provide an adequate amount of vitrified site wastes that reflect both the "average" vitreous product and "highest" anticipated radioactive product from the vitrification of site wastes. These products will be subjected to a variety of tests, including radon emanation testing.

Should vitrification be the chosen remedial treatment technology, another group of bench tests recommended to formulate a nonradioactive surrogate mixture of materials mimic the behavior of the site wastes and appropriate blends. Such a surrogate could confidently be used for engineering-scale testing at a scale large enough (nominally 20 tons/day) to accurately reflect operational conditions of the conceptual vitrification facility at the site. The use of surrogate material would circumvent any problems associated with radionuclide contamination of vendor owned equipment and could potentially be tested by a variety of vitrification equipment vendors. The reason for using such a nonradioactive surrogate material for engineering testing is that this scale of unit would be required to operate continuously over a relatively long (a few days) period of time. Such operation with actual site materials would likely constitute treatment of hazardous,

radioactive, or mixed wastes and could create a significant permitting problem and potentially undesirable negative public opinion for a location other than the site. Such problems with the use of actual site materials could be minimized by the construction of a pilot plant at the site, but design and operation of such a pilot would also benefit greatly from engineering testing with surrogate materials. Engineering testing with surrogate materials is likely to save the U.S. Department of Energy (DOE) both time and money.

6.3.3.3.3 Material Preparation Circuits. The present information suggests that the raffinate sludge, clay bottom material, and quarry soils slated for vitrification treatment will require pretreatment before introduction to the melter circuit. This pretreatment includes the physical dewatering of the raffinate sludge to nominally 80% solids and drying and sizing of all of the wastes to be vitrified. Two alternatives for material preparation have been considered: (1) thorough drying and particle size reduction of all waste materials scheduled for treatment, and (2) no preparation, feed wastes as received (raffinate) or with minimal screening (soils) or other treatment. The results of the evaluation of material preparation alternatives using MVE, observational, and data quality objectives methods are given in MVE Tables 6.3.3-7, 6.3.3-8, and 6.3.3-9, respectively.

Physical dewatering of the raffinate is the subject of Sections 5.3.5 and 6.3.5 of this report. Various *Feasibility Study* support studies (Ref. 34, Ref. 121, Ref. 122, and Ref. 123) indicate that it is advantageous to attempt such dewatering for both processing and economic considerations. For example, it is advantageous to remove some of the soluble constituents such as nitrate, fluoride, and chloride from the raffinate sludge to reduce the amount of acid gases that require treatment in the off-gas system. If such removal is not affected by dewatering, these compounds can be treated in the off-gas system. It is simpler, however, to partially remove them, if possible, during a physical dewatering step. Additionally, feasibility study sensitivity studies have indicated that it is cost effective to physically remove some of the water from the raffinate sludge, followed by thermal removal for the remainder, rather than to thermally remove all of the water. However, if dewatering to 80% solids content is not practicable via physical dewatering methods, the thermal drying techniques in conjunction with other pretreatment circuits presented here could be used to increase the solids content of the raffinate to the desired level. The remaining pretreatment requirements and their related process circuits are discussed in this section.

Conceptually, current plans are to dry all of the wastes to be vitrified to approximately 99.5% solids and reduce their particle sizes to nominally minus 1 mm. One drying and sizing circuit will be designed exclusively for the pretreatment of dewatered raffinate sludge and another for the treatment of both clay bottom material and quarry soils. An iron debris removal system has been incorporated into these conceptual designs to mitigate fouling of drying and sizing equipment.

It is appropriate at this point to discuss the overall philosophy for waste pretreatment. Waste pretreatment consists of two separate tasks that may or may not be conducted simultaneously: drying and size reduction of the melter feed. It appears to be prudent to dry the feed to the melters for a number of reasons. First, melters currently in operation at industrial scales equal to that required for site waste vitrification (nominally 100+ TPD) use feed materials similar in composition to site wastes, and these feed materials are also used in the glass-making industry. All glass-making feed materials used, regardless of melter type (FFHCM or JHCM), are dried prior to melting. This dryness allows for more accurate monitoring of the blending ratios of feed materials and results in consistently good product quality. Drying of feed materials is also beneficial in that blending of two dry solids (raffinate and soil/clay) is operationally simpler and more efficient than blending one relatively sticky material (clay) with a relatively fluid material (raffinate). Therefore, from a product quality standpoint, feed drying is appropriate for the vitrification of site wastes.

Secondly, any water remaining in the feed to the melter will generate high temperature steam. A large volume of this steam would necessitate handling much larger volumes of off-gas in that treatment circuit. Again, treating this steam in the off-gas circuits can be done but would likely require larger and more costly equipment and generate an increased amount of residual waste in the form of scrubber blowdown liquors to be handled. Slurries having very small solids content (5%-25%) are directly introduced to melters in the vitrification of spent process fluids from high level nuclear materials processing (Ref. 123). These solids are greatly diluted (5-20X) with dry fritted glass formers to form a vitrified product. These high level waste streams are also very well characterized and have consistent chemistries when compared to site wastes. The amount of glass produced from such processes is on the order of a few tons per day, which is much smaller than that required for site waste vitrification. Therefore, the current design for the vitrification facility for site wastes includes feed drying as a pretreatment requirement. Vendors of the FFHCM, PAT, and JHCM technologies are planning engineering- and pilot-scale programs at other DOE facilities to evaluate melting of slurries of waste materials to determine

operational impacts of such to their melters; this topic is discussed further in Section 5.3.3.4.2, Melter Circuits.

Similar arguments can be made for the size reduction pretreatment requirement for site wastes. Again, regardless of melting technology (FFHCM or JHCM), the glass industry uses feed that is uniform and fine grained (nominally, minus 1 mm). A uniform fine-grained material melts more rapidly and uniformly than a material of variable grain size and is much easier to monitor and blend, thus creating a good quality product. Uniformity problems can be somewhat minimized through the use of a glass residence tank. Further melting can take place in this tank, and the resulting melt may become more homogeneous. Essentially, a trade-off exists between particle size and melting and glass formation time. The reliance upon such a tank to improve uniformity for melting a feed of significantly variable chemistry may not be advisable for site waste. Such a tank may, as discussed in Section 5.3.3.4.2, exacerbate the unwanted formation of immiscible phases in the melt. The PAT systems are currently believed to be more robust in their ability to accept larger sized materials than either the FFHCM or the JHCM melters. This is due partially to the higher melt temperatures achieved with a PAT system, and partially because of the bowl-like morphology of the PAT reactor (in Retech's system), which is somewhat analogous to the glass residence tank mentioned previously. Vendors for FFHCM, PAT, and JHCM technologies are also planning engineering- and pilot-scale programs to evaluate melting of waste materials with variable grain sizes to determine their operational impacts, and to determine the quality of the product produced in their melters. This is also discussed in Section 5.3.3.4.2 Melter Circuits.

As with all developing technologies, advances in design and operation improve those technologies, and it is expected that such advancements will in time allow for the vitrification of waste materials with less rigorous pretreatment. At this juncture, it is appropriate to include the waste pretreatment requirements of drying and sizing in the site vitrification conceptual design until technological advancements are made that negate or reduce these pretreatment requirements.

Information from the chemical solidification/stabilization MVE session (Ref. 122) has been used in the design of some of the pretreatment circuits. The raffinate pit clay bottom material will likely require more extensive pretreatment than the quarry soils. Although this material has not been well characterized, it is prudent to consider that at an in-place moisture content of approximately 20% of this clay-rich material may be very difficult to handle and

process within a size reduction facility. For example, a wet clay could agglomerate into relatively large balls that could adhere to screw conveyor blades, screens, and melter paddles, causing operational problems. Consequently, it is presumed that staged drying of this material to minimize its cohesion will be required. Clay bottom material will therefore be disaggregated, passed through a screw-type indirect hot-oil dryer and then through an impact crusher to a covered temporary storage pile prior to final size reduction and indirect drying for melter feed.

The quarry soils will be passed over a scalping grizzly, through the impact crusher to the covered temporary storage pile prior to final size reduction and drying for melter feed. Only one circuit is required from the impact crusher through final size reduction and drying for the treatment of quarry soils and clay bottom material, since it is likely only one of these materials will be processed at any given time. This circuit has been designed to accommodate the vitrification of soil and clay at rates consistent with the vitrification of this material blended with raffinate or vitrified alone, i.e., 490 tons of solids per week (blended) and 980 tons of solids per week (alone).

The raffinate sludge requires a dedicated pretreatment circuit due to its different handling characteristics, as compared with soil/clay, and to the need to blend it as a dry solid with soil/clay dry solids prior to vitrification. This circuit assumes that the raffinate sludge will be delivered to the pretreatment circuit at a rate of 490 tons of solids per week and will have an average of $\geq 80\%$ solids content. As stated previously, if the raffinate dewatering facility does not achieve the goal of 80% solids, the drying equipment in this pretreatment circuit can be modified to accommodate whatever physical dewatering is practicable, if any. Dewatered raffinate will be introduced to this circuit through an impact crusher for delumping before conveyance to a covered temporary storage pile prior to final drying and size reduction for melter feed.

Indirect drying of all waste materials will be required to minimize off-gas treatment requirements and has been incorporated, wherever possible, into the vitrification conceptual design. All grinding and conveyance circuits are designed as enclosed units to mitigate fugitive dust emissions. All dry waste storage bins have HEPA filtration units to mitigate fugitive dust emissions. All pretreatment circuits are sized to require operation during two eight-hour shifts/day for 5 days/week and 52 weeks/year to feed melters for 24 hours/day, 7 day/week, 52 weeks/year operation at 80% of vendor quoted capacity. The capacity of the pretreatment circuits can be easily increased to allow for higher melter throughput by occasionally adding a

shift. The roller mills are adjustable and allow for variability in the physical characteristics of the material to be ground to achieve the desired final particle size. The indirect oil-heated screw dryers also allow for variability in feed moisture content by adjustment of the oil temperature and its flow rate through the dryers.

6.3.3.3.4 Radon Control. The relationship of radon emissions to vitrification treatment has not been evaluated. Radon is one of the prime radiologic hazards at the site and it is likely that any radon remaining within waste to be vitrified would be released during vitrification to the off-gas system. Control of radon in the off-gas treatment system is the least practicable solution for radon control (see Section 6.3.3.3.8); control of radon or its removal prior to melting is advantageous and is discussed in Sections 6.3.2.3.3 and 6.3.5.3.3 for wet materials. Control of radon during mixing or agitation of the waste materials by removal of entrained gases and passing them through carbon to allow attenuation is the most practical radon control solution. Such control would likely occur during a number of remedial operations such as excavation, dewatering, storage, drying, and further storage prior to vitrification treatment. However, radon emission from solids during melting must be evaluated through additional bench and pilot testing. After vitrification, radon emissions are greatly reduced and are not likely to require control if placed in a relatively short time period (i.e., hours) (Ref. 34).

Minimal data has been collected to date that can be used to evaluate radon emissions from the above unit operations (G. Schmidt, August 12, 1992, Appendix A). This data could be applied to the estimation of radon emissions from excavation and possibly dewatering activities, but more information is required to accurately assess the radon emissions from dried waste forms and agitation required to release radon from stored wastes prior to vitrification. It is currently anticipated that radon control would be limited to carbon filters installed on enclosed waste storage units, if radon removal is determined to be required and effective at these points.

6.3.3.3.5 Storage and Blending Circuits. Alternatives for storage of waste materials were not evaluated in detail because the relative simplicity, operation, and good availability of a variety of bins, silos, and other storage types. These devices must be enclosed for dry materials and have adequate capacities. Storage capacities that are estimated to be required for the continued operation of the facility are discussed later in this section. Staged storage is advantageous because it allows the vitrification facility to operate uninterrupted during periods of downtime in excavation activities because of equipment failure, inclement weather, or labor problems. The staged storage also allows the melter to operate continually for periods

of downtime during equipment failures in waste pretreatment circuits. Staged storage is an important concept for vitrification, because melter downtime is usually related to failures of the refractory, which is greatly exacerbated by frequent thermal shock created during start-up and shutdown of operations.

Alternatives considered for waste blending included mechanical and static blenders; static blenders were selected for the design. Advantages of static blenders include minimal maintenance requirements, consistency in operation, and lack of power requirements. It is currently thought that physical flow controllers will provide adequate waste metering accuracy and precision; these flow controllers will also generate real-time blending information to the operators, which will support treatment quality assurance requirements and allow the operators to modify the waste blending strategy, as required. Specific data on the exact nature of blending required for vitrification does not yet exist; it is recommended that such information be collected during engineering- and pilot-scale testing programs.

Waste materials will be temporarily stored at three separate locations within the facility prior to vitrification. A minimum of 9.6 days of waste is stored within the pretreatment circuit plus a minimum of 5.8 days of pretreated melter feed allows for a total storage capacity of a minimum of 14 days of waste materials. The following discussion outlines the storage and blending requirements for each of the three waste forms, quarry soils, raffinate pit clay bottom material, and raffinate sludge.

Quarry soils. The quarry soils will be stockpiled at the TSA after excavation of the quarry. A front end loader equipped with a 5 cu yd bucket will be used to transfer quarry soil to the VIT pretreatment facility where it will be screened, crushed, and then conveyed to a covered temporary storage pile which will accommodate 1500 tons of as received soil (80% solids), the equivalent of 1200 tons of dry soil (100% solids), or 9.6 days of melter feed, when vitrifying soil alone, or 19 days of melter feed when vitrifying soil blended with raffinate. Quarry soil will be conveyed as required from the temporary storage pile to the final drying and size reduction circuit and then pneumatically transferred to one of two 300-ton storage silos, which hold 600 tons or the equivalent of 9.6 days of melter feed when vitrifying quarry soils blended with raffinate, or 4.8 days of melter feed when soil is vitrified alone. This silo will then pneumatically transfer pretreated soil through the static mixer to one of four 45-ton melter feed bins (two per melter, each equipped with load cells) on demand. These 45-ton bins store the equivalent of about one day's melter feed. Therefore, when this storage and pretreatment

system is operating, approximately 14 days of melter feed is internally available. During periods when the clay bottom material is excavated, quarry soil will not be accepted at the vitrification pretreatment circuit.

Clay bottom material. The raffinate pit clay bottom material will require some stockpiling immediately following its excavation. Clay bottom material will then be introduced to the VIT pretreatment facility by a front-end loader equipped with a 5 yd³ bucket, where it will be initially disaggregated, partially dried, crushed, and then conveyed to the above mentioned covered temporary storage pile which will accommodate similar amounts of clay bottom material as it does quarry soil. The clay bottom material will be handled and stored in the same manner, using the same treatment circuit as for the quarry soil.

Raffinate Sludge. The dewatered raffinate sludge will be accepted at its dedicated pretreatment circuit, delumped, and conveyed to a covered temporary storage pile, which will accommodate 750 tons of as received (80% solids) material, the equivalent of 600 tons of dry raffinate, or 9.6 days of melter feed. It will be conveyed, as needed, to final drying and size reduction and then be pneumatically transferred to a 300 ton storage silo or the equivalent of 4.8 days of melter feed. This silo will then pneumatically transfer pretreated raffinate through the static mixer to one of four 45-ton melter feed bins (two per melter, each equipped with load cells) on demand. These 45-ton bins store the equivalent of about 1 day of melter feed. Again, when this pretreatment and storage system is operating, approximately 14 days of melter feed is internally available.

The availability of a minimum of 9.6 days melter feed in the initial storage piles is somewhat arbitrary, but is a reasonable quantity of material to have on hand in the event weather, equipment, or labor problems should stop excavation activities at the site. The sizes of the storage equipment could easily be changed to accommodate some other capacity if so desired. The bins have been sized by estimating densities of the material to be stored. If these estimates are significantly different from test results during final design efforts, these bins can easily be resized.

6.3.3.3.6 Melter Feed Circuits. Two alternatives were considered for melter feeding systems: mechanical systems and pneumatic systems. Pneumatic systems were selected for the design; however, both systems could be adapted to the vitrification facility. Pneumatic systems are advantageous for a number of reasons, including their use of positive air pressure

to transfer feed to the melter and their minimal amount of mechanical equipment requiring maintenance. FFHCM systems have a back pressure that must be overcome for this feeding to occur; therefore, pneumatic systems can be easily adjusted to overcome a variable back pressure that may come from the operation of melters at variable throughput. Mechanical systems, using equipment such as screw feeders (conveyors) with pressure fittings, could be used, but would require high maintenance and periodic replacement of many of the moving parts; pneumatic systems have lower maintenance requirements, and therefore, less anticipated down time.

The pneumatic feed systems, one for each melter, include piping and connections to each of the storage bins for each melter. Connections at the melter include one-way check valves to allow flow from the bins to the melter, but not back flow from the melter into the feed system. Connections at each melter storage bin allow the melter to be fed from either of the bins. If one of the bins went out of service for a period of time, the melter could be almost continually fed from the other bin with downtime occurring only during that bin's filling cycle, which is estimated to be less than 0.5 hour. This flexibility, again, lends robustness to the design.

The previous discussion did not address the introduction of other types of feed material such as drummed liquid or solid waste, or the introduction of limestone for melting with soil/clay when raffinate is not available, if such should be determined to be advantageous. The vitrification system will be capable of treating an as yet undetermined amount of site wastes other than the raffinate, soil, and clay bottom material. It is anticipated that these materials will include unused process chemicals such as the tributyl phosphate, that may or may not be radioactively contaminated, but will need to be disposed of during site remediation. These materials may be liquids or solids. It is anticipated that the solid materials would be bled into an appropriate point in the appropriate solid pretreatment stream (raffinate or soil/clay) as determined by their chemical constituents. Liquid waste materials, again depending upon their composition, could be fed in small quantities into the final drying and sizing circuits for the solid or possibly injected directly into the melter.

Limestone or other fluxing material should be melted with soil/clay when raffinate is not available and the soil/clay would otherwise be melted alone, it is anticipated that this fluxing material could be added via the raffinate circuit, and additional or more complex or costly pretreatment, storage, and delivery systems would not be needed. Crushed limestone (minus 4 in.) could be added directly to the feed hopper for the impact crusher at the front end of the

raffinate pretreatment circuit. Real-time adjustment of the melt temperature would allow for any blend and melt temperature aberrations which might occur during transition between feed blends.

6.3.3.3.7 Product Discharge Circuit. The fritted product was determined to be optimal for the conceptual design because it is likely to meet performance criteria, is stable at ambient temperature, will not shatter and create a working hazard, and can be easily handled using conventional earthworking equipment. Other products, such as shaped or containerized forms, are also viable waste forms. These waste forms would require additional unit processes. Specialized handling would also be required for these alternate waste forms during waste placement within the disposal cell. The evaluation of alternatives for the product discharge system is given in tabular form on MVE Tables 6.3.3-10, 6.3.3-11, and 6.3.3-12.

Using the selected alternative, molten waste glass will exit each melter in a stream that is directed to a common fritting reservoir. This molten glass will be quenched in a water bath in that reservoir to produce a frit. The water in this bath will be cooled in a cooling tower and recycled back through the quench circuit until the dissolved solids content increases to the point where it may threaten to damage pumps or other related equipment. The frit will be lifted from each melter's fritting reservoir to a common temporary storage bin by a screw conveyor system that will also remove drainable water from the frit. The temporary storage bin will accommodate 15-tons of fritted glass or the equivalent of approximately two hours of melter production. If necessary, a simple draining reservoir within the temporary storage bin could accommodate any additional drainable water, if it should exist. The temporary storage bin is equipped with a remote dump system to load trucks which will transport it to disposal. This dump system will be monitored by the operator who will be in communication with the truck driver via radio. The trucking capacity must be greater than the 15 ton capacity of the bin. This can be accomplished by having: (1) one 15-ton truck make a trip between the melters and the disposal once every 2.5 hour, or (2) having more trucks with less capacity make the trip more frequently, or (3) one truck with more capacity could operate less frequently.

6.3.3.3.8 Off-Gas Treatment Circuits. The conceptual design for the FFHCM vitrification off-gas system is based on the assumption that the off-gas consists of large particles, submicron aerosol composed largely of condensed volatile metals, and acid gases, as is the case for all high temperature waste treatment processes. Furthermore, throughout this conceptual design attempts are made to minimize nonvitrified residual wastes by recycling waste streams, such as scrubber sludge and HEPA filters, to the melter to the greatest extent possible.

However, since volatile and semivolatile metals and metalloids vaporize at melter temperatures, they would build up to unacceptable levels if not removed. Therefore, a key design feature of all systems considered for this application is capture and recycle of larger, entrained particles by a primary scrubber of moderate, size-controllable efficiency, followed by high efficiency scrubbing of submicron aerosol, highly enriched in volatile metals, which is then removed from the system.

Off-gas treatment systems must be designed specifically for the overall system that they will be used with. These systems must be designed to accommodate the type and amount of particulate matter, volatile metals and metalloids, and acid gases that are the function of the material melted, its physical and chemical characteristics, and the melter and type of fuel used. For example, the seemingly slight differences in melter equipment morphologies can have a significant impact on the type and size of equipment selected for off-gas treatment. Additionally, specific information regarding the actual composition of such an off-gas resulting from the vitrification of site wastes does not yet exist. Estimates of the composition of such an off-gas have been used for this conceptual design; however, these estimates cannot be relied on for design of the actual off-gas treatment system. Engineering- and pilot-scale test results must be obtained prior to design of the off-gas treatment system for full-scale production. For these reasons, the discussion of off-gas treatment circuits required for vitrification of site wastes is largely limited to a discussion of systems that represent different off-gas treatment strategies, rather than detailed discussions of optimal equipment selected for design.

A modified value engineering session was held to evaluate the off-gas treatment technology best suited for use with a FFHCM system. Proposed technologies had to meet the following given criteria:

- Off-gas is from melters fueled by natural gas.
- Melter feed material is physically dewatered to 20% water content and thermally dewatered to 1% water content.
- Radon control, if necessary, will be before the melter and off-gas treatment circuits.
- Melter and off-gas system will operate 24 hours/day, 365 days/year with 90% up-time.

- Raffinate, raffinate pit clay bottom material, and quarry soils will be vitrified.
- There will be an off-gas treatment system for each of the two melters and each melter throughput will be 100 tons/day maximum (dry weight basis).
- Best available control technology will be required for removal of SO_x and NO_x from the off-gas stream.
- Organics will be adequately controlled in the melter system.
- The system will be protective of public and worker health.
- All applicable or relevant and appropriate requirements will be met.
- Melter will have a recuperator (if feasible) to recover some heat from the off-gas for pre-heating combustion air.
- High-efficiency particulate filters will be used for final filtration on the end of any off-gas system.

The following off-gas treatment systems suggested by vendors and used in other hazardous waste thermal treatment applications were evaluated.

- Low Pressure Drop Venturi/Tandem Nozzle Scrubber (TNS).
- Low Pressure Drop Venturi/Collision Scrubber (COLS).
- Low Pressure Drop Venturi/Centrifugal Scrubber/Wet Electrostatic Precipitator (CENS/WESP).
- Low Pressure Drop Venturi/Ionizing Wet Scrubber (IWS).
- Quench Scrubber/Spray Dryer/Dry Venturi/Baghouse (SD/DV/B).
- Low Pressure Drop Venturi/Packed Bed Scrubber (PBS).

- Spray Dryer/Fabric Filter (SD/FF).
- Spray Dryer/Electrostatic Precipitator (SD/ESP).
- Spray Dryer/Baghouse/Low Pressure Drop Venturi (SD/B/LPV).
- Spray Dryer/Baghouse/High Pressure Drop Venturi (SD/B/HPV).
- Low Pressure Drop Venturi/Wet Electrostatic Precipitator/Low Pressure Drop Venturi/Ionizing Wet Scrubber (WESP/IWS).
- Air or Spray Cooling/Dry Scrubber/Cyclone/Electrostatic Precipitator/Fabric Filter (DS/C/ESP/FF).
- Submerged Bed/Packed Tower (SB/PT).

The low pressure venturi represents any low-fouling quench scrubber. Final specification of the quench scrubber used is dependent upon deposition or fouling potential at the melter/off-gas treatment interface. The extent of this fouling should be determined during pilot testing.

Criteria were developed to evaluate the above technologies. The criteria were compared to each other using a numerical system that ranked them in order of importance. The first 10 criteria (major criteria) were used to evaluate the alternative off-gas treatment technologies. The last five criteria (minor criteria) were numerically ranked much lower than the others and were not used in the initial alternative evaluations. The criteria considered during this development phase of the MVE session are listed below in order of relative importance.

- Control efficiency for volatile metals.
- Control efficiency for particles prior to HEPA filters.
- Mechanical availability of the off-gas system.
- General safety of the system.
- Control efficiency for mercury.
- Residual waste produced by system.
- Control efficiency for acid gasses.
- Operability of system.

- Ease of adding NO_x control.
- State of technology.
- Other considerations:
 - Relative energy consumption.
 - Reagent consumption.
 - Control efficiency for NO_x.
 - Labor requirements.
 - Ease of adding HEPA filters.

RESULTS AND CONCLUSIONS

Each off-gas treatment alternative was scored for each of the above major criterion; the final rankings are:

<u>Technology</u>	<u>Final Rank</u>
SD/DV/B	1
TNS	2
COLS	3
IWS	4
SD/B/HPV	5
WESP/TWS	6
PBS	7
DS/C/ESP/FF	8
SD/B/LPV	8
CENS/WESP	10
SB/PT	11
SD/ESP	12
SD/FF	13

The quench scrubber/spray dryer/dry venturi/baghouse system scored highest. The advantages of this system were in residual waste reduction and control of acid gases. A disadvantage of the system was its limited use in the mixed-hazardous waste field. The results

of the MVE evaluation of alternatives including observational approach and data are given in MVE Tables 6.3.3-13, 6.3.3-14, and 6.3.3-15, respectively.

As shown, the spray dryer/baghouse/high pressure venturi system had a lower score than the pressure venturi/wet electrostatic precipitator/low pressure drop venturi/ionizing wet scrubber system and the low pressure drop venturi/packed bed scrubber, but it has a higher final ranking. This is because the SD/B/HPV system is used at various other hazardous waste facilities and the team felt the PBS system could potentially have plugging problems. Additionally, the WESP/IWS system has two state-of-the-art components the team felt were not yet fully tested.

The evaluation team agreed that the top five systems could treat the off-gas waste stream very easily, and that the other technologies may also be applicable. A further detailed analysis, including heat and material balances would need to be performed to determine which one of these systems (if any) would be incrementally superior to the others.

The MVE team recommended that more information be obtained both from vendors and other remediation facilities about the recommended off-gas treatment systems. Specifically, the team was particularly concerned about residual waste composition and quantities. Other items for further study include:

- Comparison of order of magnitude capital and operating costs for the top five systems including reagent consumption, energy, labor, and maintenance costs. Deliverables would include preliminary process flow sheets and associated energy and material balances.
- Representative statistical analysis of the feed material including an estimate of mercury contamination.
- Define which NO_x control system is best suited for application with each off-gas system and relative cost and advantages of each NO_x system.
- Determine if the vendor's design of the melter's recuperator meets our needs or if it would be advantageous to redesign or omit the recuperator.
- Comparative analyses of air versus liquid quench for initial cooling of the off-gas.

- A pilot test of the proposed melter to determine the following:
 - Partitioning between melt and off-gas for all constituents of concern.
 - Particulate carry over from the melter to the off-gas treatment system.
 - Deposition on outlet pipe/recuperator.
 - Excess air rate for melter under actual operating conditions.
 - Ability of the melter to recycle by-products from the off-gas system. These by-products would include solids and minor amount of volatile metals.

During the formulation of the functional analysis system technique (FAST) diagram, the team also discussed process equipment and process parameters that could be changed or modified to minimize off-gas treatment requirements. Only off-gas treatment for FFHCMs was considered. The particular vendor version or specific equipment selected for the melter type also significantly affects the off-gas produced. It was concluded the optimum equipment would require minimal excess air for operation and minimize particulate carryover. Additionally, process parameters such as operation temperature and whether additives are used also would affect the characteristics of the off-gas produced. The cyclonic melter design selected allows for rapid temperature adjustment and can operate at the minimum temperature required for the waste being treated at the time. Also, the use of additives is currently considered unnecessary because conductivity is not critical. However, adding a simple flux, such as crushed limestone, when the soil/clay material is melted without raffinate sludge, may be necessary to reduce the melting temperature of the soil/clay.

Descriptions and discussions of the implementation of a NO_x reduction system and the top four off-gas treatment technologies follow.

NO_x OUT

A NO_x reduction system is probably required as a part of the off-gas treatment technology regardless of which off-gas treatment system is selected for controlling other acid-gases, particulates, and volatile metals and metalloids. NO_x reduction is required if the

incinerator has the potential to emit over 40 tons of NO_x a year. The NO_xOUT system is one of two systems available to remove NO_x from the off-gas stream. This system is probably preferable, because it uses urea as a reagent and the other system uses ammonia, which is somewhat hazardous to store. The system would be first in line in any of the off-gas systems, since the temperature required for the NO_x reduction reaction is in the range of 870 to 1150°C with an ideal temperature of 925°C. Urea is injected into the off-gas in this temperature range and converts the nitrogen oxides to nitrogen, carbon dioxide, and water.

Top 4 Off-Gas Systems

Quench Scrubber/Spray Dryer/Dry Venturi/Baghouse Technology (1)

The Quench scrubber/spray dryer/dry venturi/baghouse technology is widely used in the glass manufacturing industry and appears to be advantageous for site application. Research Cottrell, a SD/DV/B manufacturer, has also applied this technology to the hazardous waste industry (Research Cottrell, March 4, 1992, Appendix A).

The SD/DV/B system works as follows. Off-gas from the melter is cooled to 1150° to 870°C by directly injecting atmospheric air. A NO_xOUT solution is injected at a temperature of 925°C. The off-gas is then cooled even further by exchanging heat with the saturated off-gas exiting the submerged scrubber at approximately 66° to 71°C. The submerged off gas is reheated to 230°C to reduce humidity.

To time SO_x the gas is dried to contain a moisture level of .1 lb of H_2O /lb of dry gas. The dried gas proceeds to the R-C Teller system. The R-C Teller system consists of a quench reactor, dry venturi, and a baghouse. Sulfur dioxide will be removed in the quench reactor through the injection of lime droplets from three nozzles. The addition of lime reduces the amount of SO_2 , HF, and HCl, and removes a large portion of the particulate matter. Adequate residence time is provided to maintain a dry bottom system and to achieve the desired air pollutant removal. The waste products up to this point in the system can likely be recycled back into the melter.

The Dry VenturiTM is a spool-like piece in the ductwork. Telsorb (limestone plus propriety additives) reagent is injected into the Dry Venturi to capture the submicron particulates as well as hydrocarbons. The Telsorb acts as both a reagent and a cake modifier, providing a

low-compressibility layer of solid that exits to the baghouse. The Dry Venturi also provides an additional stage of acid gas neutralization. Very high humidity in the gas can blind filter bags in a baghouse; therefore, a very effective dry system is an ideal choice.

A baghouse follows the Dry Venturi. Baghouse temperatures are below the fusion temperatures for volatile metals (except mercury). The baghouse acts as a reactor for additional removal of SO_2 , and as a final particulate collecting device. Particulate cake on the bags also acts as a fixed bed reactor for completing the acid gas neutralization process. Baghouse dust would not be recycled back to the melter because it contains a majority of the volatile metals, which have partitioned to the off-gas system.

A HEPA filtration system follows the baghouse. The HEPA filters assure that 99.97% of the radionuclides that may still be entrained in the off-gas after passing through the R-C Teller system are removed prior to release to the atmosphere. This HEPA system also includes prefilters which protect and extend the life of the HEPA filters.

Since this is a dry system, one of its major advantages is that there is minimal water to remove from the waste before it is recycled back to the system, resulting in fewer unit processes on the overall system. Further, fabric filter systems have inherent advantages in collection efficiencies, insensitivities to gas stream fluctuations, and simple operation. Disadvantages of the fabric filter system have been minimized by placing the quench reactor and dry venturi in front of the baghouse. This limits problems with temperatures and acidic particulates or gases. This system may have slightly higher maintenance requirements since bags will have to be replaced (Ref. 124).

Tandem Nozzle Scrubber and Collision Scrubber (2) and (3)

The next two systems are essentially the same in conceptual design. They both include proprietary wet scrubbers and have both been used at hazardous waste sites worldwide. Manufacturer of the tandem nozzle scrubber is Hydro-Sonic. Calvert manufactures the collision scrubber (John Zinc Co., 1991 and 1992; Appendix A and Ref. 125).

The Tandem nozzle scrubber works in the following manner. Steam is atomized into the waste gas stream forming water droplets of about the same size as the particulate. The gas stream then enters a turbulent contact zone in which the particles are wetted and vapors

adsorbed. Particulate growth then takes place in an agglomeration zone. Actual removal of the agglomerated particles is accomplished in a specifically designed low pressure cyclone. Water and particulates are gravity drained from the cyclone bottom, and the cleaned gasses exit through the top. Because steam is used in this application, power consumption can be as much as 10 times greater than that required for an air injector venturi. For an estimated off-gas volume of 16,000 acfm at 1500°C, the steam ejector scrubber would use an estimated 6,250 lb/hour (100 psig saturated) of steam to limit particulate emission to 0.015 gr/dscf (John Zinc Co. 1991, Appendix A).

Particulate removal in this treatment system improves with decreasing throughput in the melter. Lower emission rates can also be obtained if the amount of steam delivered to the venturi is increased. Water requirements are 25 gpm at 60 psig for scrubber quench portion and 27 gpm at 20 psig in the scrubber itself (John Zinc Co. 1991 and 1992, Appendix A). After the initial quench, the system operates at 180°F. Removal of vapor phase mercury will be less effective at this temperature than at a lower temperature. The high efficiency of this scrubber should result in long HEPA filter lifetime.

The Calvert Flux-Force/Condensation system is advertised as ideal for heavy metal removal, because the gas temperature is typically cooled to below 50°C. It was developed by Calvert especially for use in industrial and medical waste incineration installations. The system takes advantage of the available moisture of the gas stream to condense some of the water vapor on the particles, causing their mass and diameter to increase. This makes the particles much easier to collect. The rest of the condensing vapor sweeps particles with it as it moves towards the cold surface.

The hot flue gas from the incinerator is immediately quenched to near its adiabatic saturation temperature with fresh and recycled water in a direct contact quencher. Solids from the quencher are filtered and recycled to the melter. This rapid quenching minimizes the potential for post-combustion generation of dioxins for high chloride waste streams. The quenched gas is then passed through a condenser/absorber for acid gas removal and condensation of heavy metals such as lead, cadmium, and mercury for collection. The condenser/absorber uses wet-film, cross-flute structured packing which provides the required thermal and mass transfer without plugging.

The partially treated off-gas continues to the Calvert Collision Scrubber. This scrubber uses collision forces to create extremely fine droplets with large surface areas, resulting in efficient collection of particulate and acid gases. No spray nozzles are used allowing scrubbing liquid to be recirculated without the usual problems of plugged nozzles and piping.

The Calvert Waveform entrainment separator, which effectively collects the fine droplets while operating at a low pressure drop, is the next device in Calvert's recommended system. An optional wet electrostatic precipitator (WESP) can be added after the separator. Final particulate emissions are claimed to be less than .03 gr/dscf with HCL removal of 99% and SO₂ removal efficiency of 85%. Pressure drop across the system is 60 in. (Ref. 125).

Large system turndowns are achieved through a draft control system that monitors the melter draft and recycles the gas from the fan outlet to the collision scrubber inlet. The collision scrubber will automatically run at or above the design scrubber pressure at any melter off-gas flow rate.

Most of the water in the Calvert system is recirculated; the only exception is the initial saturator, where makeup water is needed. Calvert felt that about 275 lbs/hour of concentrated blowdown would need to be processed, but this is probably very dependent on the feed material.

Wet systems in general have the following advantages: There are no secondary dust sources as with baghouse unloading, relatively small space requirements, ability to collect gases as well as particulates in high temperature and high humidity gas streams, and achieve high collection efficiencies for fine particulates. Disadvantages of the wet system are: increased water disposal, corrosion, higher pressure drop, high horsepower, solids buildup at the wet-dry interface, and relatively high maintenance costs (Ref. 124).

Ionizing Wet Scrubber (4)

The ionizing wet scrubber (IWS) removes fine particulate matter and acid gases at low energy levels and high collection efficiencies. Ceilcote uses this system in numerous municipal waste incinerators handling a variety of wastes.

Before the gas enters the IWS, the gas stream is quenched with a low pressure venturi scrubber to temperatures of 82°C to 93°C. Gases then pass through a prescrubber. In the

prescrubber, the gas is fully saturated with water vapor and the coarse particulates are removed. The prescrubber also serves to remove the particles that form due to condensation or gas phase reaction, and also to remove entrained liquids.

Incoming off-gases pass through a high voltage ionizing section which imparts an electric charge to the droplets and particulate matter. As the charged particles move through the scrubber, they are attracted to the surface of the packing material or to a liquid droplet and are captured. The captured particles are removed from the system by a continuous cross flow of scrubbing liquid. The scrubber is ideal for the removal of volatile metals (including mercury) as it operates at a temperature of about 49°C (Ref. 126).

The scrubber liquid is recirculated by a pump and fresh liquid is added to balance evaporative losses and to keep absorbed gases in the recycled liquid at a low enough level to maintain efficient gas absorption. An integral sump receives the scrubber liquid after the liquid passes through the packed bed. This sump recirculates the liquid within two minutes to three minutes.

The collection efficiency of an IWS is only slightly lower for small particles than it is for large particles. The IWS is a fractional collector (removal is a percentage of incoming load). Additional stages can be added to improve overall collection. If one stage achieves a reduction of particulates by 90% (typical), three stages would reduce particulates by 99.9%.

Reagents can be added to the scrubbing liquid to improve removal efficiency for certain constituents. Some NO_x control may be achieved in this manner through wet chemical reactions. This type of NO_x control is not believed to be adequate for the currently perceived site need.

The initial capital cost of an IWS scrubber is slightly higher than traditional fine particle wet scrubbers. The operational costs, however, are usually much lower because the IWS scrubber operates at a lower pressure drop.

HEPA filters are needed at the end of the system for final particulate control; therefore, a heater would need to be installed to raise the temperature of the off-gas to about 180°F and lower the humidity.

Unrecyclable Material

A spreadsheet was developed to estimate the amount of unrecyclable residual waste and emissions to the atmosphere that would be generated by the off-gas system.

Spreadsheets for two systems were developed. One is a dry system and one is a wet system. The dry system is based on the dry venturi/baghouse (RC-Teller) system described above. It is essentially a dry bottom system, with minimal impacts on the water treatment budget of the site. The wet system would be based on either of the wet scrubber systems described above. This type of system might have an impact on the site water treatment budget as the scrubber waste may need dewatering before further remediation activities. The actual gallons of water per hour that would be needed for input to the system and amount to be treated is estimated to be between 20 gpm and 25 gpm.

Three soil contamination levels were used for this evaluation: Case I, Case II, and Case III. All three cases assume raffinate sludge and quarry soils would be fed to the melter in equal proportions on a dry weight basis; this is a conservative method in that it is likely that less than a 50:50 ratio may be used due to the lesser amount of raffinate when compared to soil/clay scheduled for treatment. Case I assumes the weighted average concentrations of constituents in quarry soils and raffinate sludge were used. This gives the best estimate of the long term average emission rate and residual quantity. Case II used the highest raffinate sludge pit average and the average quarry waste concentration. In Case III, the highest average concentrations, plus one standard deviation from the raffinate pits, and the highest quarry concentrations were used to provide short-term upper limit "worst-case" emission and residual waste estimates.

An uncertainty in these calculations is the collection efficiency of various pollution control equipment. To take this into account, a range of reasonable control efficiencies were used. To obtain the highest amount of recyclables, control efficiencies in the first scrubber were set to the low end of the range and the efficiencies for the second scrubber were set to the high end. To minimize the residuals for further treatment, the opposite was used (Ref. 127). Further information is required from engineering- and pilot-scale testing to determine accurate control efficiencies for specific constituents using specific equipment types.

To effectively collect acid gases such as SO_2 and fluorides and chlorides, a slurry of lime (in the case of the wet system) or crushed limestone (dry system) is used. The amount of lime

necessary to reduce the amount of incoming acid gas was calculated and this mass added to the system. Ten percent over the stoichiometric requirement was used for lime slurry and 20% over the limit was used for crushed limestone.

Eight scenarios were run and the results are given in Table 6.3.3-16. As shown there is a potential for about 75 lb to 240 lb/hour of unrecyclable sludge for a long term average with potential maximum of over 400 lb/hour on the short term. These sludge production rates correspond to 0.9 tons to 2.9 tons/day (approximately 0.8 yd³ to 2.7 yd³) for the long-term average, and 4.9 tons/day (4.5 yd³) under maximum conditions (Ref. 82).

6.3.3.4 Operational Uncertainties. Although a facility and treatment process may be extensively tested, during full-scale operations the unforeseen often arises. The design of the conceptual plant incorporates the ability to treat variable waste types. In general, various problems that could lead to insufficient or an unacceptable product, or otherwise lead to schedule delays, will be examined and the mitigative efforts discussed. The majority of operational uncertainties are related the ability to operate a complex system that will produce a product with very predictable quality.

6.3.3.4.1 Product Quality. The results from literature searches and actual bench-testing vitrification programs using samples of site wastes indicate that the product produced from the vitrification of site wastes will easily pass the TCLP performance criteria. However, more work is required prior to determining the optimal waste blend and product formulation for this application. Such further work is necessary and is discussed in Section 6.3.3.4.3. A blend of waste materials with the appropriate amounts of contained glass-formers is, however, very likely to produce the quality of vitrified product necessary. Extreme variations in chemical composition of the waste materials outside the range that is currently known could, however, cause the vitrified product to fail TCLP criteria. To eliminate such failures, bench and pilot scale testing would be performed on samples which do cover the entire range of chemical composition. Such testing may include additional sludge characterization. Quality control parameters and related operating values would be developed as part of bench and pilot testing in place of TCLP testing.

6.3.3.4.2 Equipment Operation. This conceptual vitrification facility is in many ways similar to a small-scale mineral processing-type milling circuit coupled with a medium-scale glass plant. Both of these types of systems are operated independently worldwide with

great success. A combined system, such as the conceptual design presented here, is not in operation at any known waste site. Such lack of combined operating history does not, however, preclude such a system's success. The long-term operational history of the two basic industries that provide the facility design, mining and glass-making, is excellent and is indicative of success at such a vitrification facility.

Large increases in the content of constituents of the waste materials that are related to off-gas and melter corrosion (Cl,F) outside the range that is currently known could, however, cause more rapid destruction of the refractories or off-gas system ductwork than is currently allowed for. Such a situation would require appropriate repairs and a possible change in materials of construction or refractory formulation. This corrosion could also lead to more downtime for repair than is currently planned. Downtime greater than the 39 days/year allowed with the conceptual design is unlikely, but could be mitigated by increasing the melter throughput. Such increases have been previously discussed and it is probable that melter throughput could be increased to 180 tons/day of solids and still operate the melters at 90% of the vendor quoted capacity. This increase in throughput would allow up to approximately 112 days of downtime instead of the 39 days maximum expected. In this scenario, the pretreatment circuits would have to be operated three shifts per day instead of the planned two, increasing the capacity of the off-gas system and additional stockpiling of the waste materials either prior to introduction to the melter or prior to pretreatment would have to be accommodated. A radical change to the system operation, as has been described is very unlikely, but is possible.

Failure of the off-gas system is as equally unlikely as the above scenario, because the final system would be tested during both pilot- and full-scale startup operations and designed with sufficient margin of safety. If a component of the system failed to operate correctly, the melter circuits effected would require shutdown until repair was affected. It is unlikely that both melter circuits would require shutdown at the same time for such a cause. If however, the waste stream chemistry changed drastically without any prior indication, resulting in off-gas release potentially exceeding allowable limits, both melter circuits would be shut down immediately. An evaluation of the problem would be conducted and if necessary, the off-gas system would be retrofitted with the appropriate devices prior to startup. Such a problem could likely be remedied by a temporary change in the waste blending ratio.

Other less drastic problems related to operation of the system are failure of one or more pre-treatment system components. Such a failure would likely require shutdown of only that particular circuit and not the entire facility. Downtime resulting from such an equipment failure could be made up by operating that particular circuit for additional shifts.

6.3.3.4.3 Future Vitrification Testing. The above discussion states that additional bench and pilot scale vitrification testing is required. This section discusses some of the proposed future testing bench and pilot scale testing and the associated cost and time required.

Further testing is required of vitrification technology prior to its implementation at the Weldon Spring site. Such testing would include bench and pilot-scale programs. Three types of vitrification technologies have been considered for site wastes: Fossil fuel-heated ceramic melting, plasma arc torch melting, and joule-heated ceramic melting. The relative development of these technologies, as discussed in Section 5.10.3.6, indicates that FFHCM and PAT are closer to large-scale implementation than is JHCM. The response from all vendors indicated that surrogate (nonradioactive material) testing could be conducted at a number of facilities at scales large enough to provide operational information for design purposes.

Vitrification Bench Scale Testing Program

Previous bench scale treatability studies have been conducted by Pacific Northwest Laboratories (Ref. 34) and are currently underway at the Vitreous State Laboratory of the Catholic University of America (Ref. 80). Results of this testing have shown that site waste materials can be successfully vitrified. Results from these programs also indicate that some further bench testing should be conducted to evaluate the treatment of waste materials representing the extremes in the chemical variability of site wastes. These results have been discussed throughout this TID and were used to prepare this conceptual design. The majority of this testing has been conducted as crucible melt tests or in very small scale JHCM units. It is important to conduct treatability testing using treatment equipment that is of similar morphology to equipment that would be used in full-scale waste processing.

It is recommended that multiple contracts be awarded for vitrification bench-scale test programs. This recommendation is made to evaluate both melter technologies that have been identified as most applicable to site wastes, FFHCM and PAT, at engineering-scale.

A detailed discussion of the proposed bench scale work can be found in the Task 830 report (Ref. 128).

Vitrification Pilot-Scale Testing Program

Following the previously described bench-scale testing program, a pilot-scale testing program is recommended for the vitrification treatment methods chosen for further consideration in the treatment of site wastes. This pilot program, as described in the statement of work for Task 830, requires constructing a fully functional, nominal 5 tons/day capacity melter of the morphology chosen for potential full-scale processing of site wastes. This melter would be operated on site and owned, at the completion of testing, by the DOE. It may be advantageous, from an engineering design perspective, to use a larger size melter system to obtain more accurate operating information than is possible with a smaller unit.

Alternative Vitrification Testing Programs

Further discussions with vendors of vitrification technology indicated that alternative treatment testing programs should be considered. These alternative programs could increase the level of knowledge gained through these testing programs. Such alternative programs would make the best use of available equipment and add confidence to the engineering, design, and construction of a full-scale vitrification treatment facility. These alternatives are also likely to significantly reduce, and possibly eliminate, the costs to the site for testing, design, and construction of a full-scale vitrification facility at the site.

Duratek's Alternative Testing Program (JHCM)

Duratek representatives have suggested an alternative treatment testing program that would eliminate the design and construction of a small-scale pilot facility, but would utilize a 1 ton/day (tpd) melter and then a half-scale (50 tpd) melter to determine operating parameters and design adjustments for the full-scale plant. The 1 tpd unit was operational in July 1992, and the 50 tpd unit is scheduled to be operational July 1993. Neither unit would be able to conduct testing of actual Weldon Spring site radioactively contaminated wastes, but Duratek is confident that surrogate testing would be adequate to determine information required for the engineering, design and construction of a full-scale vitrification facility for the site. They anticipate that this approach would provide advantages in terms of cost, adherence to schedule, and developmental

risk minimization. Unfortunately, Duratek is currently limited to testing JHCM technology, and the most favorable vitrification technologies for site wastes are FFHCM and PAT technologies.

Vortec's Alternative Testing Programs (FFHCM)

Vortec representatives have discussed two alternative treatment testing programs that both include bench-, engineering, and pilot-scale testing. The first alternative would result in the construction and operation of a 20 tpd pilot plant, instead of a 5 tpd pilot plant, at the site. Essentially, this program would be similar to the previously discussed program, but would eliminate the construction and operation of a 5 tpd pilot plant. Vortec currently has a 20 tpd plant at their University of Pittsburgh's Advanced Research Center (UPARC) facility which could be used to determine operational parameters for the 20 tpd site pilot plant; operation at the UPARC facility must be limited to the treatment of materials, which are not radioactive wastes. The UPARC facility is planned for use in the development of the 5 tpd pilot, however, it may be advantageous to go directly to the design and construction of a 20 tpd pilot plant for use at the site. This would increase program costs; however, such a program is advantageous because of the significantly larger treatment facility, which could be operated as a full-scale waste vitrification facility at approximately 20% of the capacity planned for the operation of one of the two melters currently considered in the full-scale treatment scenario. The major disadvantage of this approach is that the melter could not be efficiently operated continuously at a low throughput of approximately 5 tpd; it could however, be operated for short durations (hours) to evaluate processing characteristics of a variety of waste materials.

The second Vortec alternative testing program, and the one that may be the most beneficial for site, would be to participate in their DOE Morgantown Energy Technology Center (METC) program. Vortec has secured a three phase METC contract to conduct bench-, engineering-, and pilot-scale testing for an as yet undetermined DOE waste site, which would result in the design, construction, and operation of a full-scale vitrification treatment facility at the undetermined site. This alternative would be advantageous for the site in that the cost for development through construction of a vitrification facility would be paid for through the METC contract and not by the DOE/Weldon Spring site.

6.3.3.5 Vitrification System Analysis. This section presents a summary discussion of the operational aspects of the conceptual vitrification facility and how those

activities impact other remedial actions. Similarly, this section discusses how the vitrification operations are impacted by other operational activities.

Raffinate Sludge Processing

The dewatered raffinate will be transferred from the dewatering facility to the vitrification treatment facility via a conveyance yet to be determined. It is important that the dewatering circuit performs within the above limits. If the dewatering facility cannot achieve 80% solids, modifications to the drying circuits within the vitrification facility may be necessary as has been previously discussed. A reduction of the moisture content below 20% would not create any operational problems for the vitrification facility and would actually reduce the load on the pretreatment circuit.

Quarry Soil Processing

Optimally, soil should be delivered to the vitrification facility with no more than 20% moisture, as higher moisture content may require increased energy consumption in the drying portion of the pretreatment system. Alternatively, very wet soil can be processed using the modification of the circuit designed for processing the raffinate pit clay bottom material. It is not generally believed that high water content in the soil will be a problem. Free water that may exist in this soil, as excavated from the quarry, will drain from the soil while it is temporarily stored in the TSA. Recognizing that this soil will be exposed to the weather at the TSA, a simple examination of the soil during and after rainfall should be adequate to determine its acceptability for treatment in the conceptual quarry soil pretreatment system. Such an examination could easily be conducted by the front end loader operator in charge of soil transportation to the vitrification facility. Quarry soil delivery to the vitrification facility from the TSA must be directly to the system at the processing rate, as no staging area exists for as-received soil at the vitrification facility. Oversize material removed at the grizzly will require transportation and placement in the disposal cell; it is currently envisioned that this material will be an insignificant amount of the quarry soil. Until testing is completed to determine the particle size distribution and chemical analysis of the different size fractions, this issue will continue to be contentious.

Clay Bottom Material Processing

Currently, no staging area exists for as-received clay bottom material at the vitrification facility; therefore, this material requires treatment at the rate it is excavated or stockpiling at or near the excavation area or the TSA. Clay bottom material containing residual raffinate sludge will be processed as clay bottom material; excess water, if any, will be removed in the clay bottom material modification segment of the quarry soil pretreatment circuit.

Water Load From Vitrification Facility to Site Water Treatment Plant

It is currently anticipated that a total of approximately 25 gpm of contaminated water will be sent continuously to the site water treatment plant from the vitrification facility for treatment prior to release. It is likely that some of the water from the vitrification facility would need to be diverted back to the raffinate pits to keep the dredge afloat or be used in the off-gas treatment system.

Off-gas Treatment Circuit's Impact on Other Site Activities

The off-gas treatment circuit is anticipated to impact the overall water balance for the site or the VIT facility. Approximately 20 gpm to 25 gpm of water are estimated to be required for operation of the scrubber circuits; it may be possible that some of this water demand could be satisfied by using water from the drying operations in the physical pretreatment circuits. Some residual waste will be generated by the off-gas treatment system; it is currently anticipated that this material will be stabilized by the addition of cement in drums. This drummed and solidified waste will be placed the disposal cell.

OTHER INTERRELATIONSHIPS

Water Treatment Plant

The operation of the proposed conceptual vitrification facility impacts the overall site remediation plan. For example, the proposed vitrification treatment system will remove all of the moisture from the wastes during feed pretreatment or the vitrification process itself. This water will be contaminated and may require treatment prior to release. Consequently, the lack of consumption of the in situ water contained within the raffinate or the soils will have an impact

on the sizing and operation of the site water treatment plant. The removal of this water does, however, significantly reduce the final tonnage and volume of the waste materials requiring disposal.

Waste Excavation Plan

The proposed vitrification facility also has a significant impact on the waste excavation activities. Various wastes will need to be provided at approximately the designed throughput capacities of the vitrification facility. This facility has been designed to match a treatment schedule of approximately four years. However, large variations in the daily excavation rates are undesirable due to the need to stockpile excess excavated wastes, causing secondary handling of this material, and the potential for increased dust generation.

Site Grading and Stockpiling

The proposed location of this conceptual plant, requiring an area about 160 ft x 440 ft, near the eastern edge of Raffinate Pit 3, will impact the proposed site grading plan in that this area will need to be prepared for the plant construction. The 440 ft length of this area could be reduced by other configurations of the equipment. Further location studies may identify a more optimum VIT plant location from that proposed. An area about 150 ft x 250 ft will be required for the VIT plant lay down facility, which should be located near the VIT plant location. Removal of, and possible stockpiling of, contaminated soil occurring within the proposed VIT facility and laydown areas will be required prior to initiation of construction activities. Stockpiling of vitrified waste will be required if cell placement activities cease during winter months.

Treatment of Additional Wastes

The possible vitrification treatment of the contaminated tributyl phosphate (TBP) within the melter may negate the need to transport these materials off site for incineration. Additionally, the potential exists that listed wastes presently stored on site may be processed through the vitrification facility obviating any form of off-site treatment or disposal for these materials. Treatment of additional wastes is specifically discussed in Sections 5.3.7 and 6.3.7.

Site Roads Study

This task also impacts the design of site roads in that transport of excavated raffinate pit clay bottom material from the pits to the vitrification facility and quarry soils transferred from the temporary storage area to the vitrification facility will be required and at a rate dictated by the operating capacity of the vitrification facility. Reagents such as lime for off-gas treatment, or equipment may need to be delivered from the southeast entrance to the VIT plant. A road system has been designed around the vitrification facility that will connect to the overall site road pattern. The delivery roads will be kept uncontaminated, which may necessitate, at most, only a tire washdown and a hand-held radiometric scan of the tires at the site exit, prior to the trucks being released from the site. The additional truck traffic caused by any deliveries may increase road maintenance efforts, although such traffic is anticipated to be minimal. Alternatively, a pneumatic transfer system could be employed to transfer the reagents for off-gas treatment, and equipment could be transferred through the CMSA, thereby eliminating the need for a clean road.

Grout from Off-Gas Treatment

The proposed vitrification facility will produce a lime-based sludge from the treatment of acid gasses during off-gas treatment. It is anticipated that this material will be similar to a cement-like grout, will be placed into the disposal cell and that it would solidify in the cell. The quantity of this grout is estimated to be relatively small (600 tons/year), but could possibly aid in the placement of waste. Fluid grout, for example, can be used to fill voids in placed building debris. Use of this grout would help obviate the need for extensive hand placement and compaction of waste around odd shaped debris fragments and possibly allow the placement and encapsulation of relatively large fragments, which, of course, impacts the required size reduction of building debris and large rock fragments. The physical and chemical characteristics of this grout are unknown at present and represent another data need to be satisfied during pilot testing prior to final design. Whereas this grout will not be as strong as a cement-based grout, its strength should be sufficient to help minimize settling of the building debris. This lime-based cement-like grout may require treatment prior to disposal, and such treatment is likely to be similar to chemical solidification/stabilization technology studied for the site. A grout prepared by CSS technology would be stronger than the lime-based grout.

Waste Placement

The VIT product is a fritted granular material which could be handled and worked in a manner similar to that for noncohesive soils. This material does not have a time constraint on placement, and would therefore, not constrain the waste placement effort. For example, if placement activities were slowed or halted for some reason, the VIT product could be easily stockpiled until such placement activities resume.

The conceptual vitrification facility would require the trucking of the glass frit (160 tpd) and any co-produced lime-based grout (1.6 tpd) to the disposal cell, therefore an adequate trucking fleet would be needed to avoid hampering the vitrification facility productivity.

Site Surface Water Control

The site surface water control design has included the needs of the vitrification facility in terms of containing precipitation in contact with the facility and directing run-on water away from the facility.

6.3.4 Size Reduction

6.3.4.1 General. This task, as stated in Section 5.3.4.1, reflects the results of work completed in the existing contracts for building demolition Work Packages 255, 256, and 257 along with the main objective of sizing all dismantled demolition materials for subsequent placement in the disposal facility.

The following categories represent the 19 material groups for size reduction and segregation:

Material

Group

Material

- | | |
|---|--|
| 1 | Friable asbestos-containing material and man made-mineral fiber. |
| 2 | Vehicles, engines, and similar types of miscellaneous equipment. |
| 3 | Stainless steel |
| 4 | Pipes |

- 5 Miscellaneous metals
- 6 Non-metal debris
- 7 Sheet metal
- 8 PCB contaminated material
- 9 Select materials
- 10 Nonfriable asbestos-containing material
- 11 Asbestos-containing material
- 12 Structural steel
- 13 Plate steel
- 14 Rubble
- 15 Railroad rails
- 16 Large wood pieces
- 17 Wood (special)
- 18 Miscellaneous non-metals
- 19 Special metals

6.3.4.2 Operational Requirements. This section identifies the operational requirements for size reduction. All material groups are sized, sorted, and labeled at the building dismantlement and demolition temporary construction staging area before being transported to the specified storage areas. These same operational requirements are considered suitable for all other size reduction requirements, such as removal of foundations.

Operational activities required for the sorting and sizing of all waste material will take place on existing slabs-on-grade or pavement, and shall provide the necessary working surfaces for one or both of two temporary construction staging areas, depending on the structure being dismantled:

1. Interior staging area: located within any building that requires a control zone for friable insulation removal and packaging. Decontamination shall be required of all containers and equipment prior to removal.
2. Exterior staging area: an area (staging area) will be designated outside of buildings that are being dismantled for sorting, sizing and accumulating all materials prior to transportation to the appropriate storage facility.

Table 6.3.4-1 Size Reduction Material Identification details each material group.

There are no advantages to reducing debris beyond the size necessary for handling, placement, and disposal in the cell. Therefore, a size reduction facility is not required. Further size reduction may be required at the MSA to facilitate decontamination of selected dismantled material. If processing structural steel becomes possible at Oak Ridge, TN, steel lengths will be reduced from 30 ft to a maximum 12 ft length.

No special equipment is required for sizing, sorting, handling or transporting the dismantled and demolition materials. Standard construction equipment, such as front-end loaders, dump trucks, electromagnets, roll-off boxes, hoe rams, jaw crushers, cutting torches, and mobile shears are the major types of equipment currently required.

6.3.4.3 Size Reduction System Analysis. The potential for deviation or conflict from the preferred alternative is considered remote because of flexibility available through the operational procedures outlined in Work Packages 255, 256, and 257. Any problems that may arise during the size reduction operations for dismantled debris will be reported to the PMC.

6.3.5 Dewatering

6.3.5.1 General. The operations related to dewatering the raffinate sludge are confined to the functions of the various devices described in Section 5.3.5. The basic operational functions are:

- Feeding the sludge (associated with the dredging operation).
- Passing this material through the dewatering process, including the actual dewatering activity.
- Transporting the dewatered product to the CSS or VIT treatment plant.

Other related activities may include removing and transporting oversized material from the classifier to the TSA or to the disposal cell and conveying water (removed from the sludge) back to the raffinate pits, the CSS plant, or the SWTP.

The dewatering plant design is based on the feed parameters necessary to accommodate the CSS or VIT processing plant. An estimated 59,400 tons (dry) of raffinate sludge will require dewatering. The approximate quantities of sludge present in the various raffinate pits are shown in Table 6.3.5-1.

6.3.5.2 Operational Requirements. Operation of the dewatering facility requires a continuous supply of raffinate sludge from the dredging operation and a demand of the product for the CSS and VIT treatment plants. Current assumptions are that the dredge will operate to meet the demands of the CSS or VIT plants and that the dewatering plant will produce a sufficient amount of product to meet this demand.

Based on CSS grout production rate of 80 tons/hour at a mix ratio of 1:0.4 sludge to binder, the dredge would operate 16 hours/day (two shifts), or 14.5 effective hours per day, for nine months/year pumping at approximating 400 gal/minute. Alternatively, to avoid dredging after daylight, the dredge could operate at a higher pumping rate (which almost all dredges do) with adequate slurry storage for flocculation and dewatering during the CSS plant operation.

The major concern related to this operation is the release of radon into the atmosphere as the dredge churns through the sludge. For the VIT plant, the dewatering plant will operate for nine months/year, but will produce enough feed for one year; the excess material from the dewatering plant will be stored. The VIT plant will operate 24 hours/day, 7 days/week. Safety and operating efficiency are the major concerns.

The material balance for the CSS plant was based on data in Section 5.3.2 and Section 6.3.2.

6.3.5.3 Dewatering Operations. The seven basic steps of the dewatering operations and the evaluation of alternatives were discussed in Section 5.3.5. The basic operations are:

- Remove metals (iron and steel).
- Classify (screen) the sludge.
- Store the sludge (optional).
- Add flocculent.
- Mix/blend the sludge and flocculent.

- Thicken the sludge.
- Mechanically dewater the sludge.

These operations will be performed automatically, with the possible exception of flocculent addition. Although this activity may be automated, an operator will be required to monitor the correct amount and mix of flocculent being added.

6.3.5.3.1 Dewatering Devices. Dewatering the raffinate sludges prior to CSS or VIT treatment is necessary to:

- Minimize CSS reagent use.
- Prepare a dense and pumpable solid.
- Minimize VIT energy consumption.
- Decrease CSS or VIT plant size.
- Provide a consistent and reliable feed.

The various functions of the various components of the dewatering process discussed in Section 5.3.5 are listed in Table 6.3.5-2.

6.3.5.3.2 Reagents. The only dewatering operation related to the reagents is the addition of those reagents to the treatment plant. This activity may be performed automatically by a measuring device, but may also require the presence of an individual to monitor this process. The function of flocculants was described in Section 5.3.5.5.4.

6.3.5.3.3 Radon Emissions. The only operations related to the radon control system are inherent within the devices themselves. The proposed dewatering process is only applicable within an enclosed system which prevents radon from escaping into the atmosphere. The process is composed of three independent circuits. The first circuit consists of the addition of desiccant to remove water vapors from the radon emissions. The primary gas has a negative pressure adsorption, mainly for organics, and a secondary circuit for static adsorption and decay of radon daughters. The secondary system operates continuously, balancing the headspace gas from the raffinate sludge storage tanks by compression and expansion. The purpose of the third stage circuit is to treat/decay the volume of storage headspace gas which exceeds the capacity of the secondary circuit. The radon emission control system is shown in Figure 5.3.5-2. There will be radon detection and monitoring devices installed within the system.

6.3.5.3.4 Product Discharge. There is no specific operation related to the discharge of dewatered sludge; it is the final product of the dewatering process. This product may be pretreated, but not dewatered sludge, dewatered product for the CSS treatment plant, or dewatered product for the VIT plant, as previously described in Section 5.3.1.

6.3.5.4 Dewatering System Analysis. The analysis of the dewatering system components shows no indication of conflicts occurring within the process. The only uncertainties within the system relate to the adequate functioning of the various devices; a malfunctioning device may cause schedule delays.

The two interfaces, however, that have a significant impact on the dewatering operation are (1) the excavation of the raffinate sludge (i.e., the dredging operation), which is discussed in Section 5.2, and (2) the product demand, discussed in Section 5.3.2 for CSS and 5.3.3 for VIT. Delays or problems in the excavation of the sludge will impact the dewatering operation if a sufficient amount of sludge cannot be delivered for processing; this will consequently impact the treatment plant feed. Similarly, delays in the treatment plant feed operation may impact the amount of product from the dewatering activity. As long as the waste treatment plant operations continue, however, the dewatering facility will be able to accommodate different demands. No major system analysis deficiencies were identified.

6.3.6 Decontamination

6.3.6.1 General. The no action alternative was selected as the preferred alternative for decontaminating structural steel, railroad rails, and plate steel. No action was preferred because it provided worker safety, minimized labor and generated no residual waste. In addition, the no action alternative would be the least expensive. Concrete was assumed to be volumetrically contaminated, and no method was identified for decontaminating volumetrically contaminated concrete.

The following back-up operation describes a liquid grit blasting system for decontaminating steel with large, flat, undamaged surfaces. The system is simple to use and operate, minimizes the danger of airborne contamination, and is an accepted industry decontamination method.

6.3.6.2 Operations. The decontamination system will consist of a building containing a staging and scanning area where the steel materials will be scanned for surface radioactive contamination; two chambers with liquid abrasion blasting equipment; and a system for collecting the residual contamination, spent grit, and water for subsequent treatment.

Estimates were developed for waste generation and the time required for decontamination of steel based on the following assumptions.

- Approximately 33% of the 31,000 tons of steel may require decontamination.
- Approximately 33% of the 31,000 tons of steel will be releasable without additional decontamination.
- Approximately 33% of the 31,000 tons of steel will be cracked, damaged, or shaped so that it can not be scanned effectively.
- The average steel member weighs 45 lb and has a surface area of 3.25 sf/lb.
- A crew of six will work one shift (6.5 effective hour), five days/week, and 12 months/year.
- All the steel is painted with a 10-mil layer of lead and/or chromium based paint.

The 10,000 tons of uncontaminated steel will be worth \$300,000 to \$600,000, depending on market fluctuations, and used railroad rail has a present value of approximately \$250/ton.

Twelve foot lengths of structural steel or 4 ft x 8 ft sheets of plate steel will be transported approximately 300 yd from the MSA to the decontamination facility located north of the MSA (Figure 5.3.6-1). Railroad rail (probably 33 ft lengths) will be transported in one piece. The steel will be placed in a staging area inside of the decontamination building. The structural steel will be moved to the scanning area and scanned using a Geiger Mueller or alpha scintillator radiation detectors. Material that is below the release criteria will be transported off site for recycling. Material with contamination levels above the release criteria will be processed by the decontamination facility. If small areas of a steel member are contaminated they will be marked to reduce decontamination time.

The decontamination facility will contain two chambers. One chamber will contain a single manually operated nozzle for the decontamination of irregularly shaped materials or of materials with small areas of contamination. The other two chambers will be custom constructed and will contain 12 stationary nozzles. Long regularly shaped beams and rails in good condition will be moved past the nozzles on a conveyor system.

Each liquid abrasion nozzle will clean at a rate of 0.5 sq in./second using aluminum oxide grit, although cleaning rate will vary with the degree of contamination and adhesion of the contaminants.

Approximately 9,375 lf (210 tons) will be removed from the MSA per week. It is assumed that approximately 33% or 70 tons will be unsuitable for decontamination and be stored for placement in the disposal cell. Another 70 tons will be uncontaminated and may be transported off site for recycling. The remaining 73 tons will be processed by the decontamination facility, scanned, and then transported off site for recycling. Material that fails to meet release criteria after decontamination will be reprocessed by the decontamination facility or transported to the disposal cell. Approximately 500 lb of spent grit and 8.5 cu ft of paint chips will be generated each week (Figure 6.3.6-1).

The decontamination facility will process approximately 3,125 lf/week (70 tons). The facility will commence operations once building dismantlement is completed, and during disposal cell and waste treatment (CSS or VIT) operations. Space is limited at the chemical plant site, therefore, early operation of the decontamination facility will clear space at the MSA for other activities.

Approximately 142 weeks would be required to decontaminate 10,000 tons, approximately 33 of the 31,000 tons of steel at the Weldon Spring site. Approximately 440 weeks would be required to decontaminate the entire 31,000 tons of steel.

6.3.7 Additional Treatments

6.3.7.1 General. On-site and off-site treatment processes for treating and disposing of wastes that are not detailed in other studies include:

- Deactivation using on-site water treatment systems.

- Stabilization or chemical precipitation with on-site water treatment systems.
- On-site solidification or vitrification followed by on-site landfill disposal.
- Off-site incineration with on-site ash disposal.
- Off-site recycle, reuse, or energy recovery.

6.3.7.2 Summary of Additional Treatment Operations. The treatment processes described in Tables 5.3.7-1, 5.3.7-2, 5.3.7-3, and 5.3.7-4 consist of both on-site and off-site operations.

6.3.7.2.1 On-site Operations. Deactivation of oxidizers and small volumes of acids and bases can be performed in Train 1 of the site water treatment plant. A small conveyance system and material spreader is needed to prevent slug feeding that may cause excessive abrupt heat buildup and create an unsafe explosive condition. The equalization pond serving Train 1 cannot be used to deactivate wastes due to regulations governing treatment in surface impoundments.

Deactivation or chemical precipitation of ignitables, corrosives, reactives, metals, and various organics requiring intensive process controls can be accomplished using the mobile sump water treatment system. This system should be positioned near Building 434 and receive cataloged waste directly from the containers. Additional cells can be readily added to the mobile sump water treatment system to accommodate media absorption and adsorption with all solids diverted to the waste treatment plant.

A dehalogenation system with reagent preparation and drum mixing is needed to treat PCB contaminated liquids and solids. Existing 55-gallon drums will be used as treatment vessels with portable heat jackets to control reaction temperatures.

Final waste solids can be satisfactorily treated in the CSS or VIT treatment plant and the resultant solidified product placed into the on-site disposal cell.

All on-site alternative treatment processes must be coordinated with CSS or VIT plant operations.

6.3.7.2.2 Off-site Operations. Extended temporary storage of PCBs, solvents, and oils is necessary until incineration capacity becomes available at DOE's Oak Ridge facility or

other appropriate facilities. Regulatory approval will be required for extended temporary on-site storage. Liquid solvents and oils having heat content greater than 5,000 Btu/lb and water content less than 10% should be sent to energy recovery units, such as Diversified Scientific Services Incorporated in Oak Ridge, Tennessee.

If possible, transformer and capacitor shell exteriors should be decontaminated on site and shipped off site to a TSCA incinerator with metal shredding capabilities.

6.4 Site Closure

6.4.1 General

Figure 5.4-1 depicts the site conditions prior to site closure. The cell area has been fenced and a cell perimeter road constructed for maintenance purposes, and for access to the monitoring points within the fenced area. The access control building will house some of the monitoring instruments, maintenance equipment, files, and other information regarding post-closure inspections. Though not depicted in this figure, the site is graded and revegetated. The road along the site perimeter is not shown because it is uncertain whether it will remain.

In addition to monitoring the overall area, structures that will require long-term surveillance and maintenance include the disposal cell (mainly the cover), the leachate collection and removal system, roads, culverts, monitoring wells, the fence and gates, the access control building, and signs. These required monitoring activities will be detailed in the post-closure plan. The site closure activities (operations) are tied to the designs proposed in Section 5.4. These operations will be discussed in this section as part of the site closure plan. They include:

- Removal and remediation of temporary support facilities.
- Removal of existing roads and construction of permanent roads.
- Installation of groundwater monitoring wells.
- Review and establishment of final surface runoff controls (not considered in the site drainage study, Section 5.1.6).

- Establishment of final site security (fence, access control, and signs).
- Operations and maintenance.
- Removal of operating equipment.

6.4.2 Removal and Remediation of Temporary Support Facilities

The removal and remediation of temporary support facilities correlates with the designs and assumptions presented in Section 5.4.2. Removal activities involve support facilities used during construction of the disposal cell and other remediation activities; these facilities will not remain after site closure. This study proposes that the site be returned to its natural vegetative state. Therefore, the temporary support facilities must be removed and remediated to prepare the site for final grading and reclamation activities. The final objective will be to achieve the site closure conditions proposed in Section 5.4.

Temporary support facilities that may require removal as part of the site closure task include the SWTP and retention ponds, the TSA, the waste treatment facility, the Ash Pond spoils area, and the CMSA. The removal of access and haul roads is discussed in Section 6.4.3. The removal of contaminated materials and other structures, including the underground utilities, is discussed in Section 5.1.2.

Removal procedures shall conform to all applicable dismantlement and demolition procedures, specifications, health and safety plans, and regulations as previously developed and initiated by the Project Management Contractor (PMC). The removal operations for most structures will follow procedures similar to those discussed in the waste removal plan in Section 5.1.2. The following preliminary removal sequence has been developed as a basis for the conceptual design:

<u>Sequence</u>	<u>Action</u>
1	Disconnect all utilities.
2	Establish site drainage and erosion and sediment controls.
3	Establish a temporary materials staging area (may use the CMSA).
4	Remove debris inside and outside buildings.
5	Decontaminate facilities, if feasible.
6	Remove facility equipment and interior piping.
7	Dismantle, demolish, and remove above-grade structures.
8	Remove surface concrete, asphalt, and gravel pads.

- 9 Remove pond liners near the water treatment plant.
- 10 Excavate foundations.
- 11 Remove underground piping and utilities.
- 12 Remove contaminated soils, if encountered, and place in cell.
- 13 Backfill and compact excavated areas with clean soils.
- 14 Remove road asphalt, concrete, and gravel.
- 15 Remove existing culverts and drainage structures, except those that will remain for post-closure.
- 16 Construct new roads.
- 17 Install monitoring wells and abandon existing ones that will not be used.
- 18 Establish final surface runoff controls.
- 19 Establish site security.
- 20 Remove property boundary fence, if so determined in Title II design.
- 21 Seed and mulch disturbed areas.

The estimated material quantities for the temporary support facilities to be removed are shown on Table 6.4-1. Specifications that are specific to the removal and remediation of the temporary support facilities include: Temporary erosion and sediment control structures, building dismantlement and demolition, earthwork, dust control, and site work. A complete list of all operational specifications for the site closure task is presented in Section 6.4.10.

6.4.3 Site Road Abandonment

The post-closure site road system is necessary for monitoring and maintaining the site during at least the first 30 years of post-closure. Some of the existing roads will be incorporated into the final road layout, as discussed in Section 5.4.3. Generally, all existing asphalt, concrete, and gravel roads within the site are to be removed, with the exception of the existing roads adjacent to the west and east sides of the cell, the existing site perimeter road (as determined in Title II), and the existing asphalt site entrance road and portions of the parking lot near the administration building.

Removal of most existing roads is necessary to reclaim the site and return the area to its natural vegetative state. Roads that are not an integral part of post-closure monitoring and maintenance should, therefore, be removed. In addition, if the existing roads remain and the property boundary fence is removed, public access would be encouraged, which could potentially deter the growth of vegetation. A post-closure road will remain at the disposal cell perimeter for access to leachate collection sumps and monitoring wells and for cell maintenance.

Most of existing site roads are gravel roads constructed to St. Louis County Standard Specifications for Highway Construction (Ref. 46). Procedures for abandoning roads will follow

all applicable specifications and site procedures. In general, the following sequence of procedures may be performed:

<u>Sequence</u>	<u>Action</u>
1	Install temporary erosion and control measures.
2	Remove concrete and asphalt surfacing material; separate from subsurface materials for later use.
3	Remove aggregate materials and stockpile for later use.
4	Remove roadway drainage structures and place in disposal cell, if contaminated, or release and recycle if clean.
5	Regrade roadway areas to drain and conform with surrounding contours.
6	Seed and mulch all disturbed areas.
7	Remove temporary erosion and sediment control measures after vegetation has been established.

Materials such as concrete, asphalt, or gravel that may be reused for site closure road construction or other functions should be stockpiled.

Roads that will be abandoned should not be removed until after all remedial work in the vicinity of these roads has been completed. A practical plan may be to remove the roads furthest from the cell first, leaving the road leading to the final open area of the cell for removal last.

A maintenance plan will be developed for the cell perimeter road and any other roads that will remain during post-closure. This plan should include all requirements for maintaining the road and all drainage structures or related features. At a minimum, the plan will include the following:

- Inspection and maintenance procedures.
- Inspection and maintenance schedule.
- Maintenance log forms.
- Regrading road surfaces as required.
- Filling pot holes and eroded areas.

- Exterminating weeds and grasses that grow in the roads.
- Mowing each side of the road to keep brush and trees from encroaching on the road.
- Inspecting drainage crossings and cleaning out debris and sediment to maintain proper drainage flows.
- Performing any other necessary maintenance to ensure a 30-year life.

6.4.4 Site Reclamation

Following the backfilling of excavated areas with clean backfill and the final site grading mandated by surface water runoff requirements, one of the major site reclamation activities is the revegetation of the site. The details regarding the types of grasses and the criteria for revegetating the area are discussed in Section 5.4.4. This section presents the operations required to achieve the design proposed in Section 5.4.4.

Ground preparation may be required prior to cultivating any grasses. If weeds are present, the ground should be deeply plowed in late fall to eradicate established weeds. The seedbed should be firm, preferably cultipacked. The soil should be tested and phosphorus, potassium, and lime should be applied, as needed, prior to seeding. Nitrogen will not be applied because it encourages the growth of weeds. Several methods exist for reducing soil loss on erosion-prone areas while establishing native grasses. The method chosen should be implemented during other land disturbance activities preceding planting.

Planting can be accomplished by either drilling or broadcasting. Agricultural and track-type tractors with standard planting equipment, such as seeding drills, may be used for seeding and mulching operations. A rangeland drill is the most efficient means of planting. Seeds should be debarbed and mixed with phosphorus and potassium fertilizer, if broadcast seeding is to be used. The seedbed should be cultipacked before and after broadcast seeding. Most seeds should be covered with no more than 0.25 in. of soil; some seeds may remain exposed. Seeding and mulching will be performed to achieve a uniform and complete vegetative ground cover. Seeds and fertilizers will contain minimal amounts of impurities to ensure a quality product.

All native grass seeds should be purchased in pure, live seed amounts. Seeding rates will vary according to the number of species planted. Broadcast seeding rates must be 25% higher than drilled seeding rates. The seeding rate will be increased to allow for seed that will rot before spring. The best seeding dates for the types of grasses proposed at the site are from late April to early July. Seeding before May will require the use of herbicides or frequent early mowing for weed control. Fall planting is not successful until after early November.

Either native or introduced legumes and other types of forbs should be included in the seed mix. These are often added to the stand during January or February, prior to the third growing season of the native grass.

The following general guidelines should be followed:

- Sequence 1. Weeds should not be allowed to grow more than a foot tall before mowing. Mow to a stubble height of 4 in. to 6 in. the first time, 6 in. to 8 in. the second time; avoid mowing after August. Herbicides may be used to control broadleaf weeds but their use should comply with the waste minimization procedures set by the site. All herbicides should be applied according to label instructions.
- Sequence 2. Cool-season broadleaf weeds should be mowed in May. Scorching (burning) is generally not advised because grassy weeds may become worse.
- Sequence 3. Overseed legumes in January or February if they are desired. Scorch the area lightly in the early spring to kill weeds, remove dead growth, and recycle nutrients. Timing of the burn is important to achieve the desired results. Plans for the scorching need to be carefully considered to protect surrounding property.

6.4.5 Site Security

The fence, gate, and signs will be placed as determined by the contractor. Grades along the fence line should be fairly gradual, with the possible exception of drainage locations. Post holes for fencing may be drilled using a small implement tractor. Concrete for posts may be placed using a concrete truck from a local concrete plant or may be mixed and placed on location. Other operational details will be specified in Title II final design or as determined by the selected subcontractor.

6.4.6 Groundwater Monitoring and Contamination Control Wells

The operations component of monitoring wells may be divided into the following categories: well installation, completion, development, decontamination, and sampling for monitoring purposes. This section presents operations associated with the designs discussed in Section 5.4.5. The location and type of monitoring well is a design function with no field-related activity other than surveying. Some of the following subsections include lists of procedures and specifications to be followed to establish and operate a disposal cell monitoring system. The procedures and specifications are generally based on those presently in use at the Weldon Spring site, and are intended to comply with all applicable Federal, State, and local regulatory requirements. The following items will be addressed:

- Design criteria for the drilling and monitoring well installation program.
- Procedures for drilling, installing, and developing groundwater monitoring wells.
- Decontamination procedures for drilling activities.
- Criteria for the selection of sampling methods for monitoring wells.
- Procedures for sampling groundwater monitoring wells.

The final grading, cover, and surface drainage features may cause the volume of natural groundwater recharge which enters the overburden and shallow bedrock aquifers to decrease by restricting infiltration into, and directing surface runoff away from, the disposal cell. This decrease in recharge may impact water levels and the direction of groundwater flow. After the disposal cell is constructed, these impacts should be carefully monitored by water levels and by periodically constructing potentiometric surface maps.

6.4.6.1 Design Criteria for the Drilling and Monitoring Well Installation Program. Criteria were developed to support the final design of the drilling and monitoring well installation program. A number of drilling technologies are available, and certain methods are more suitable for satisfying the criteria listed below. Drilling methods for the monitoring well installation program include hollow-stem auger, cable tool, mud rotary, air rotary, coring, ODEX, reverse circulation, and dual-wall reverse circulation air. Experience gained from previous site investigations will assist in the selection of the appropriate drilling method. Design criteria for consideration include:

- Required depth.

- Hardness of formations to be penetrated.
- Well diameter.
- Sampling requirements.
- Requirements for controlling cuttings and other drilling-derived wastes.
- Necessity for preventing cross contamination of aquifer systems; certain technologies and procedures allow isolation of drilling fluids and water produced, and prevent cross-contamination of aquifers.
- Coring requirements; spot coring or continuous coring may be required to provide field data for the determination of final well design.
- Experience gained from previous drilling programs.

6.4.6.2 Procedures for Drilling, Installing, and Developing Groundwater Monitoring Wells. Procedures for drilling, installing, and developing groundwater monitoring wells were developed for previous investigations at the Weldon Spring site. Refer to the Weldon Spring Engineering procedures, Section 16.18 (Ref. 48). These procedures shall be used for installing the wells in the vicinity of the disposal cell.

6.4.6.3 Decontamination Procedures for Drilling Activities. Decontamination procedures have also been developed for drilling activities at the site and are included in the procedures mentioned above. These procedures will be used during the installation of new monitoring wells in the vicinity of the disposal cell.

6.4.6.4 Criteria for the Selection of Sampling Methods for Monitoring Wells. The criteria presented below have been developed to determine the appropriate method for sampling groundwater monitoring wells. A number of sampling technologies are available, and certain methods and equipment are more suitable for satisfying the criteria listed below. Sampling methods include bailing, bladder pumps, submersible pumps, piston pumps, and air-lift samplers. Experience gained from previous sampling programs at the site may be helpful in selecting the appropriate method. Criteria for consideration include:

- Depth to groundwater.
- Well diameter.
- Well productivity.
- Physical and chemical properties of groundwater contaminants; the method selected should ensure that volatile organic compounds are not lost during sampling.
- Durability of capital equipment.
- Manpower requirements to employ technology.
- Requirements for decontamination.
- Methods previously employed - data consistency considerations.

6.4.6.5 Procedures for Sampling Groundwater Monitoring Wells. Procedures for sampling groundwater monitoring wells were developed for previous investigations at the Weldon Spring site. These procedures are described in procedure ES&H 4.4.1s *Groundwater Sampling*. Similar procedures may be used for the post-closure sampling program. Additional procedures related to groundwater sampling include:

- ES&H 4.1.1a, *Numbering System for Environmental Samples and Sampling Locations*.
- ES&H 4.1.2s, *Chain of Custody*.
- ES&H 4.1.3s, *Sampling Equipment Decontamination*.
- ES&H 4.4.2s, *Groundwater Level Monitoring and Well Integrity Inspections*.
- ES&H 4.5.1s, *pH and Temperature Measurements in Water*.
- ES&H 4.5.2s, *Specific Conductance Measurement in Water*.

- ES&H 4.5.8s, *Water Sample Filtering.*
- ES&H 4.5.6s, *Measurement of Dissolved Oxygen in Water.*
- ES&H 4.5.10s, *Alkalinity Measurements in Water.*
- RC-30s, *Disposal of Purge and Development Water from Groundwater Monitoring Wells.*

Reporting and monitoring requirements will also include applicable sections of 40 CFR 264, Subparts F and G.

6.4.7 Surface Runoff Controls

Surface water runoff controls are discussed in detail in Section 5.1.6, Site Drainage, and the operations related to the implementation of these controls are presented in Section 6.1.6. The operations related to the placement of temporary surface runoff controls used only during the site closure activities are presented in this subsection. Control measures should be installed prior to conducting any remedial work and should remain until all work is completed and final surface runoff control measures are established.

Operational procedures for controlling storm water surface runoff during site closure may include the following methods, which are commonly used in the construction industry:

- Straw bales.
- Sand bags.
- Temporary grass seeding and mulching.
- Jute matting.
- Silt fences.
- Ditches.
- Diversions.
- Sediment basins.
- Culverts.
- Riprap.

The specific use of any one of the aforementioned methods will depend largely on the operations of the selected subcontractor. Conceptually, most of these methods are feasible and may be used, with the possible exception of temporary grass seeding; the remaining methods are easy to apply, do not require detailed design, are readily available, are commonly used in the industry, and can be quickly placed and removed. The use of equipment is minimal, possibly requiring only a backhoe tractor with a front-end loader.

Specifications that may be required in final design to address temporary surface water runoff controls are:

- Temporary surface water control measures.
- Seeding and mulching.
- Corrugated metal pipe culverts.
- Riprap.
- Filter fabrics.

6.4.8 Operation and Maintenance

The operation and maintenance requirements related to site closure activities are those that address the following structures: the disposal cell, the cell perimeter road and other roads that may be established later, the drainage ditches including culverts, vegetation, the fence around the cell area, access control, and appurtenant structures such as buildings, signs, and posts. Specific details associated with monitoring each of these components will be established in the post-closure plan; therefore, only a brief discussion is presented in this subsection.

Routine cell maintenance will be performed as required and identified during site inspections. These inspections will be performed semiannually for at least 30 years following closure. Spot maintenance will be performed as needed, at any time, following noticeable damage to the cell cover or after a major event such as an earthquake, heavy storms, and the like. (Title II work or the post-closure plan may define the need to establish an earthquake reporting system with a national organization such as the National Oceanic and Atmospheric Administration or the U.S. Geological Survey. Some unscheduled site inspections may also be conducted as part of the monitoring program. The major component of the cell that will require maintenance will be the cover; current assumptions are that only minor repair work will be

necessary. The hand tools necessary to perform this work will be stored on site, but a subcontractor may be selected to perform the necessary repairs, as needed.

The planned and unscheduled inspections will also identify repairs to the rest of the structures that may be necessary (i.e., roads, ditches, fence, gate, grass areas, etc.). Repairs to these structures will also be performed, as needed, and as described in the site inspection reports. Possible maintenance requirements may include removing grass that has grown in the perimeter road, filling pot holes and other erosion-related damage, painting or substituting posts and signs, mending the fence and gate, and conducting other general preventive maintenance. Monitoring operations for the wells are discussed in Section 6.4.5.

Maintenance requirements for vegetation following site closure will be minimal. Maintenance should entail only monitoring for signs of erosion, filling minor erosion rills or gullies, re-seeding, or some combination of these activities (Ref. 128), except for possible occasional mowing on road berms and scorching to maintain the vigor of the native grass stand.

6.4.9 Removal of Operating Equipment

Operating equipment used for site remediation activities will be removed as each activity is completed. This equipment is the responsibility of the various subcontractors and the current assumption is that each subcontractor will remove its own equipment. Planning the removal of this equipment is not practical at the conceptual or even final design stages. The schedule for removal will be determined at the completion of each activity.

A major criteria applicable to any removal activity is the decontamination of all equipment before it leaves the site. Therefore, one decontamination pad should be available for those activities immediately prior to commencing site closure operations. Operating equipment used for site closure construction activities will also be removed, as necessary, but there should be no contamination concern. Inspection for contamination shall conform to established project criteria.

If some equipment or component is determined to be contaminated and cannot be cleaned, it must be placed in the disposal cell. If the cell is closed, the contaminated material must be transported to an approved site for disposal.

Removal specifications shall consist of "Surface Cleaning and Decontamination Procedures for Equipment" and other regulatory requirements as defined in the General Provisions, General Conditions, and Health and Safety Plans developed by the site.

6.4.10 Operational Uncertainties

A major operational uncertainty that may affect the site closure plan is the potential for encountering contaminated materials after the disposal cell has been closed and sealed. An approved alternate disposal site that can accept the contaminated materials will have to be selected. Another uncertainty relates to inclement weather during the execution of site closure activities. This would delay site closure operations.

6.4.11 Specifications

Most of the specifications associated with site closure activities were presented in Section 5.4. The following additional specifications may be required for the operations and functions of the site closure activities:

- Summary of work.
- Measurement and payment.
- Quality assurance and quality control.
- Temporary facilities.
- Temporary utilities.
- Dust control.
- Temporary surface water control measures.
- Surface water control.
- Topsoil stripping and stockpiling.
- Earthwork (excavation and backfilling).
- Corrugated metal pipe culverts.
- Riprap.
- Filter fabrics.
- Surface cleaning and decontamination procedures.
- Dismantlement and demolition.
- Roads.
- Fencing.

- Site grading and preparation.
- Seeding and mulching.
- Site closure.
- Operations and maintenance.

6.4.12 Site Closure System Analysis

The operations related to site closure presented in the previous sections do not interfere with site activities. The site closure components that require evaluation from a systems analysis perspective include:

- Removing support facilities (clean material only).
- Removing existing roads and constructing permanent roads.
- Installing monitoring wells.
- Reviewing and establishing any final surface runoff controls (not considered in the Site Drainage Study, Section 5.1.6).
- Establishing final site security (fence, access control, signs).
- Revegetating the site.

The proposed schedule for performing this work is discussed in Section 5.4.8. Most of the tasks comprising site closure will be performed by subcontractors and will follow set schedules. The PMC will be responsible for supervising this work and maintaining these schedules. The current conceptual study does not identify any potential problems in completing the site closure activities.

6.5 Contractor Requirements

6.5.1 General

The contracting requirements for the remedial action at the site encompass engineering, procurement, and construction of all of the designs outlined in Sections 5 and 6. Additionally, backup activities such as surveying, maintenance, and operation of decontamination pads would also require subcontracts. This section outlines the logic for breaking up packages, the major work packages envisioned, small and disadvantaged business considerations, types of contracts, and the overall logic of sequencing these contracts.

6.5.2 Contracting Strategy

The major considerations for breakdown of subcontract packages include:

- Logical grouping of tasks/designs/activities.
- Small and disadvantaged business goals.
- Sequencing of design/procure cycles.
- Interfacing of contract activities.
- Types of contracts.

Alternatives for subcontracting include one large contract, several large contracts, multiple small contracts, or combinations of large and small contracts. Although the advantages of one large contract could include more efficient use of equipment and labor and fewer interfacing problems, the disadvantages would counter these advantages by not allowing smaller contractors to bid, and requiring all designs to be completed before bidding on the one large contract. A subcontracting strategy forum was held among PMC Engineering, Procurement, Construction Management, and Management departments to consider all of these possibilities. After looking at the activities listed according to the work breakdown structure (WBS), the rough sequence of these events, and the size of the possible work packages, the following considerations help to define how the work should be divided:

- There are several large packages that cannot be broken up because of the size/duration of the activity (e.g., waste placement, cell construction). Cost of these packages ranges well above \$3 million.

- Interfacing activities is intricate and there is potential for delays and stoppage of work if multiple subcontracts are awarded.
- Breaking up large activities may cause liability questions, interfacing difficulties, and quality assurance problems.
- Several activities are on the critical path and would be expedited if engineering designs could be started as soon as possible without waiting for the entire remedial design to be awarded.
- The bulk of construction activities occurring in the middle years of remediation will not be amenable to small subcontracts.

After consideration of these and other items, a mix of large and small subcontracts is recommended to optimize schedules, interfaces, and accountability, along with allowing as many small subcontractors as possible to bid the work.

Activities can be divided into large groupings according to the sequencing of activities. These groups would include engineering design, site preparation, construction, waste excavation/treatment/placement, support functions during remediation, and closure.

Designs of temporary structures having a Quality Level 3 designation are performed under two architecture/engineering (A/E) subcontracts. At least one additional local A/E firm is scheduled for an A/E subcontract. All long term structures designated as Quality Level 1 will be designed by MK-Ferguson Company (MKF) off-site engineering, the engineer of record for items such as the disposal cell.

The various designs would be awarded according to the breakdown of packages listed in Table 6.5-1, which shows the subcontractors for the site remedial action, as well as the possible use of small and disadvantaged businesses. Performance of a Quality Level 1 design will commence only after DOE review/concurrence of design team qualifications to perform the task.

The two large packages that are not amenable to a small contractor (Items 10 and 20) include the bulk of the construction activities in regards to size (dollar value) of the effort. For the disposal cell (Item 20), the package could be split into three packages for parts A, B, and

C. Breaking this package, however, would involve two very large contracts and one medium contract. This could cause some interference between construction (20A) effort of clean material and excavation/placement of the waste (20B). Because the total volume of contaminated material is still unknown, the flexibility of design and implementation would have to be well coordinated. The cover placement --- 20C (once all material was in the cell) could also be a separate bid item, but coordination of placement would be required. Final cover placement might not be easily phased as sections are completed. Questions on liability, delays, and interfacing complications are the serious impacts foreseen, if the large package is subdivided.

Phased Construction and Renegotiated Price

Phased construction of the disposal cell would lend itself to renegotiation of the contract at each phase. Similar to large dam constructions, the costs of construction would change over the long building period. The first phase of disposal cell construction would be awarded with subsequent Phase II and closure phase still to be detailed and costed. Earthwork (both construction and excavation of waste) should become a routine activity as work progresses, and thus later phases could be negotiated for a lesser cost. Design changes caused by unknown quantities of waste could also be implemented as the project moved into the later phases when volumes are better defined.

Contract Types

Of the three options for types of subcontracts, the type which would be selected in nearly all cases would be either:

- Lump sum.
- Fixed unit prices.

The third manner of contract types, time and materials, would be used only on a limited basis where conditions and the scope of work are not definable and/or quantifiable.

6.5.3 Contracting Sequence

The sequence for awarding subcontracts is dependent on the work plan schedule outlined in Section 11. Progression from initial site preparation and construction of temporary facilities

to excavation of building foundations and contaminated soils, construction of the disposal cell, placement of waste in the cell, and finally through closure, will necessitate a variety of contract types. Where possible, small and disadvantaged business subcontracts will be the goal.

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7 SUMMARY OF PRELIMINARY ASSESSMENTS

Section 7 presents various items associated with the conceptual designs described in Sections 5 and 6. These include safety and health, quality, environmental impacts, energy and resource conservation, uncertainties, contingencies, and additional assessments.

7.1 Safety and Health

Safety and health issues for the conceptual design involve chemical and radiological contamination, physical hazards (noise, and heat and cold stress), construction safety hazards (motor vehicle and heavy equipment operation, lifting and rigging, excavation, and trenching) and process equipment operations (stabilization of hazardous materials for final disposal).

Construction hazards should be anticipated and controlled for activities associated with the preparation of the site. These activities include excavating, transporting, stockpiling, and compacting of materials (baselock, excavated soils, and borrow materials), heavy equipment operation and use of the site roads and public highways.

The operation of the chemical solidification and stabilization (CSS) plant or vitrification (VIT) of materials has specific hazards associated with implementation. Hazards include the stockpiling of processed soil and surface materials that may result in radon exposures to workers and the environment. This stockpile will be located in an enclosed structure and will therefore require adequate ventilation. All materials and equipment in this area could become contaminated with radioactive, chemical, or airborne dust. Therefore, task-specific health and safety guidelines shall be developed for controlling exposures during these various tasks.

Several health and safety concerns are pertinent to the construction of the disposal cell. During transportation, placement, spreading and compaction, both treated and untreated waste (contaminated soils, demolition debris, friable asbestos) will contain radiological and chemically contaminated hazardous materials. Proper protective measures shall be developed prior to performing any tasks that may cause exposures to site workers. Dust control measures will be required to protect the environment and the public from dust created by the moving of debris during this project.

In addition, placement of the flexible membrane liner may create a situation that could potentially result in exposures to the workers. Depending on the type of flexible membrane liner, seaming may be accomplished with the use of solvents or through seam welding. Either method could create fumes or vapors that may be harmful to workers. Adequate control measures must be developed to maintain exposures below levels that would be of a health and safety concern to the workers. The surface of the liner could present a slip hazard. The use of ropes and/or ladders may be required to prevent workers from slipping.

Section 4.7, Environmental Safety and Health Issues, describes the elements that comprise most of the health and safety concerns for this project. Section 4.7.1, Contaminant Concentrations (Sources), summarizes the types and locations of contaminants found throughout the chemical plant site and quarry, including the radiological, chemical and asbestos hazards that exist.

Engineering controls and personal protective equipment (PPE) are used to protect site workers, the environment, and the public from contaminants found at the WSSRAP. Engineering controls are preferred for mitigating environmental safety and health hazards. These controls include the use of stringent dust control measures, such as, dust suppression techniques, localized ventilation, equipment modifications, and erosion control methods.

Where engineering controls are impractical or ineffective, the use of PPE is required. There is a minimum PPE usage requirement for the WSSRAP (refer to Section 4.7.4, Personal Protective Equipment Requirements). Upgrades in PPE usage are determined by evaluating materials to be handled, available engineering controls, work methods and conditions, material compatibilities, and exposure monitoring data.

7.2 Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) requirements/guidelines for the WSSRAP are addressed in Section 4.4 of this report. Table 5.1.7-6 lists the typical quality control requirements for construction activities that are proposed for the WSSRAP as they relate to the cell. Proposed components, parameters, test methods, and minimum test frequencies are presented; however, they are subject to change as additional information is obtained. (The list of items presented may not be complete at this time.)

7.3 Environmental

The primary mission of the Weldon Spring Remedial Action Project (WSSRAP) is to protect human health and the environment. Environmental issues have been given a high priority in the conceptual design of the disposal cell. Excavation, treatment, and removal of contaminant sources from the Weldon Spring site will ultimately have a positive environmental impact on the site; however, during remedial activities, there will also be temporary, short-term environmental impacts.

Major impacts considered during conceptual design of the disposal cell include, but are not limited to:

- Air quality.
- Surface water quality.
- Groundwater quality.
- Protection of workers.
- Wildlife and wildlife habitat.
- Noise.
- Resource commitment.

Environmental impacts common to all site remedial activities are detailed in the following sections.

7.3.1 Air Quality

During all remedial activities, water and/or dust suppressants will be used to prevent generation of airborne dust. Operation of diesel and gasoline powered equipment will emit air pollutants; therefore, all equipment will be maintained in good condition to minimize air pollution emissions and related impacts on nearby facilities.

Air quality will be monitored for chemically and radiologically contaminated particulates and radon gas at the workplace and site perimeter, and appropriate responses will be implemented if measured contaminant levels increase significantly above background level.

7.3.1.1 Construction Material Staging Area. The construction material staging area (CMSA) will be constructed during one construction season, operated during the next three to four construction seasons, and then removed following completion of the cell cover. Impacts to air quality will be minimal and short term.

7.3.1.2 Site Roads. Construction of site roads and haul roads will generate airborne dust, and operation of diesel and gasoline powered equipment will emit air pollutants. Contaminated soils will be excavated and removed from the subgrade and along the proposed route before construction of new roads; all materials will be placed in the disposal cell and the roads and surrounding areas will be graded and revegetated as a part of the remediation. Construction of the haul road from the clay borrow source area will require approximately two to three months.

7.3.1.3 Site Surface Drainage. Construction activities associated with development of the site surface drainage system will generate airborne dust. The environmental impact will last until completion of the remedial activities.

7.3.1.4 Borrow Source. The dust generated during clay borrow source area operations will, for the most part, be uncontaminated; however, the potential exists for generation of contaminated dust during foundation improvement at the site. If necessary, site roads may be paved to reduce dust generation from traffic. Dust suppression techniques, such as spraying with water, will be used as necessary.

Equipment will be maintained in good condition to minimize air pollution emissions and related impacts on nearby facilities, including the Francis Howell High School. Any environmental impacts will be short term, lasting only until completion of the borrow source operations.

Air quality will be monitored at the perimeter of the clay borrow source area as well as at the site boundary.

7.3.1.5 Waste Excavation, Handling, and Transportation. Excavation, handling, and transportation of the waste materials will cause various kinds of air emissions, uncontaminated dust, contaminated dust, radon gas, dust caused by moving vehicles on gravel road and dirt surfaces, dust blowing from moving construction equipment, and exhaust emissions

from gasoline and diesel powered equipment. Air emission problems will vary significantly with the source and nature of the contaminated materials. Removal and transportation of contaminated soils from the vicinity properties will create a risk of contaminating off-site transportation routes and other clean areas.

Vehicles transporting contaminated soils from vicinity properties will be covered to eliminate spillage and wind-blown dust. Engineering controls such as reducing working surface areas and using covers, water, or chemical agents to reduce radon and particulate emissions will be employed. Speed limits will be set for vehicles transporting contaminated materials to minimize the probability of an accidental spill and to reduce air emissions from tire traffic.

Loading areas will be managed to prevent contaminated soil from being tracked by vehicles into the clean areas. Trucks and/or truck tires will be cleaned before exiting the contaminated areas. Vehicles will be periodically maintained and inspected to minimize exhaust emissions.

In addition to the increase in air emissions due to construction-related activities, there will be an increase in automobile exhaust air emissions from employee commuter traffic along the transportation corridors including State Route 94.

7.3.1.6 Disposal Cell. Construction of the disposal cell will result in various kinds of air emissions; uncontaminated dust, contaminated dust, radon gas, and exhaust emissions from gasoline and diesel powered equipment. Engineering controls, such as reducing working surface areas and using covers, water, or chemical agents to reduce radon and particulate emissions, will be employed. Speed limits will be set for vehicles transporting contaminated materials to minimize the probability of an accidental spill and to reduce air emissions from tire traffic.

All construction materials, such as fill materials, clay from the borrow source, sands, gravel, and geotextiles from commercial sources, will be delivered to the site by truck or scraper. Non-dedicated transportation corridors, including State Route 94, will be used as haul routes for deliveries to the site. An estimated 200 to 400 employees will commute to work along transportation corridors.

Maximum containment of radon will be achieved by placement of the radon barrier to cover the waste when the waste reaches design height. This barrier and the vegetative cover

which follows comprise the cell cover. A temporary cover, such as a flexible membrane liner (FML), will cover the emplaced waste during the shutdown period between construction seasons, or when waste is left unattended for a month or more.

7.3.1.7 Dewatering. Transfer of sludge from the dredge to the dewatering plant will generate contaminated and uncontaminated airborne dust. Radon emissions control devices will be installed in the dewatering plant to minimize the amount of radon that may escape to the atmosphere. Additional air monitoring will be conducted at the site boundary.

7.3.1.8 CSS Facility. The CSS treatment facility will operate two shifts per day, five days a week, nine months a year, for approximately 23 months in a completely enclosed facility. Air quality will be monitored at the CSS treatment facility, downwind of the facility, and at the facility perimeter. Radon will be monitored at Francis Howell High School and the WSS perimeter.

There will be an increase in vehicle exhaust air emissions from trucks delivering reagents and employee commuter traffic along the transportation corridors, including State Route 94.

7.3.1.9 VIT Facility. The VIT facility will operate variable shifts: the material preparation circuits will operate two shifts per day, five days a week, 12 months a year, for approximately four years; storage and blending, melter feed, melter, product discharge, and off-gas treatment circuits will operate three shifts per day, seven days a week, 12 months a year, for approximately four years.

Mitigative measures for protecting air quality include a totally enclosed design, utilization of the best available control technology (BACT) for design of the off-gas treatment circuits, and the use of water and dust suppressants on site roads to control fugitive dust. The facility will have controlled emissions through 30 m (98 ft) high stacks.

Air quality will be monitored at the VIT facility, both within enclosed worker areas and at locations such as at the base of the stacks. Air quality will also be tracked in the interior of the facility through the use of breathing zone air samplers at a frequency determined by the WSSRAP health and safety personnel. Air quality will also be monitored downwind of the VIT facility, at the facility perimeter, and at the off-site critical receptor locations. Radon will be monitored at Francis Howell High School and the site perimeter.

All dried waste materials will be pneumatically transferred directly to bins, and mixing of waste materials will occur within enclosed systems. Storage systems for the raffinate sludges, quarry soils, and clay liner materials can be equipped with a system to capture radon emissions, if it is determined that such a system is required.

There will be an increase in vehicle exhaust air emissions from trucks delivering reagents and employee commuter traffic along the transportation corridors, including State Route 94.

7.3.1.10 Additional Treatments. The potential impacts on air quality from treatment and disposal of wastes will not differ significantly from existing and proposed on-site activities. Waste handling will generate contaminated and uncontaminated dust and radon gases. Emissions will vary by chemical material, handling procedures, and moisture content. Material handling will be managed to minimize fugitive dust and prevent spillage onto uncontaminated areas.

7.3.1.11 Site Closure. Excavation and construction activities during site closure will result in a short-term impact on the air quality. Sources of impact will include contaminated and uncontaminated airborne dust and fumes from gasoline- and diesel-powered equipment. Site closure activities will include the cell perimeter road, final grading and revegetation of the site, installation of the access control building and entrance, erection of a security fence, and the drilling of groundwater monitoring wells.

7.3.2 Surface Water Quality

During excavation, handling, and transportation of soils, good engineering practices and mitigative measures will be employed to minimize water erosion and transport of sediments to nearby surface waters. These practices and measures will include, but not be limited to:

- Surface grading.
- Berms and silt fences.
- Straw bale dikes.
- Straw, mulch, riprap, or geotextile membranes.
- Revegetation mats.

Sedimentation basins will be constructed near the site perimeter to minimize transport of sediments and/or contaminants to off-site areas. Contaminated water will be stored in lined retention ponds, and subsequently transported to the site water treatment plant (SWTP) for treatment and release; National Pollutant Discharge Elimination System (NPDES) standards will be met before water is released off site.

7.3.2.1 Construction Material Staging Area. The layout of the CMSA will be coordinated with the site surface drainage plan so that clean runoff will be directed into clean sedimentation basins via perimeter diversion ditches.

7.3.2.2 Site Roads. The layout of site roads will be coordinated with the site surface drainage plan. The final form of mitigation will be determined in consultation with appropriate State and Federal agencies. Surface water runoff from dirty roads will be directed to sedimentation ponds.

7.3.2.3 Site Surface Drainage. The layout of the site surface drainage system will segregate runoff from contaminated and uncontaminated sources. The final form of mitigation will be determined during Title II design and in consultation with appropriate State and Federal agencies.

7.3.2.4 Borrow Source. Runoff from construction activities associated with the borrow source operations could transport uncontaminated soils to the nearby surface water and wetlands. Wetlands areas that exist in and around the clay borrow source area will be protected from sediment laden runoff by good engineering practices and mitigative measures.

A State of Missouri storm water permit will be required prior to the start of any construction activities at the clay borrow source area.

7.3.2.5 Waste Excavation, Handling, and Transportation. During excavation, handling, and transportation of contaminated soils, good engineering practices and mitigative measures will be employed to minimize water erosion and transport of sediments to nearby surface waters.

7.3.2.6 Disposal Cell. Some activities associated with construction and operation of the disposal cell may impact the quality of surface waters. Contaminated and uncontaminated

soils may be transported to nearby surface water retention ponds during cell operation and maintenance. Good engineering practices and mitigative measures will be employed to minimize water erosion and transport of sediments to nearby surface waters.

Placement of the cover system will have no impact on water quality. Run off from precipitation on the cover system during its construction will be discharged.

7.3.2.7 Dewatering. The quality of surface waters may be impacted by dewatering activities. Good engineering practices and mitigative measures will be employed to minimize water erosion and transport of sediments to nearby surface waters.

7.3.2.8 CSS Facility. Washdown water from machinery cleanup at the end of each shift will be collected and used in the CSS process. Mitigative measures for protecting water quality include control of runoff from the CSS process area. Any excess rainwater will be diverted for treatment at the SWTP.

7.3.2.9 VIT Facility. The amount of water anticipated to be required for daily cleanup activities is minimal. The water generated from the thermal drying operations is anticipated to require treatment at the SWTP. Some water will be generated in the product discharge circuit from the occasional bleed required from the quench tank water system. No process-related waters are planned to be discharged prior to treatment at the SWTP; therefore, the VIT facility should have no impact on the WSS surface water quality.

Mitigative measures for protecting water quality include control of runoff from the VIT treatment process area. Any excess rainwater will be diverted for treatment at the SWTP.

7.3.2.10 Additional Treatments. Remedial activities will take place in Building 434, or adjacent to the site water treatment plant Train 1 (SWTP1), preventing releases to surface water.

7.3.2.11 Site Closure. The quality of surface waters may be impacted by site closure activities. Runoff from contaminated roads, temporary structures and foundations, and other civil works may transport sediment and contaminated soils to surface water containment areas and wetlands in the vicinity.

7.3.3 Groundwater Quality

Excavation and removal of contaminant sources from the site will ultimately improve groundwater quality at the site. During excavation, handling, and transportation of contaminated materials, the disturbed areas will drain to lined retention ponds, and the water will subsequently be transported to the SWTP for treatment and off-site release; NPDES standards will be met before water is released off site. Groundwater quality will be monitored during all phases of construction. Spills will be promptly cleaned up.

7.3.3.1 Construction Material Staging Area. The CMSA will be a clean area; therefore, rainfall landing on the CMSA area and seeping through to the groundwater will have a minimal effect on groundwater quality. One of these minor effects may be changes in pH caused by runoff from stored limestone aggregates.

7.3.3.2 Site Roads. No new site roads will be constructed prior to clearing the subgrade of contaminated soils. Contaminated site roads will be excavated when they are no longer needed, and the materials added to the disposal cell. This minimizes the source of contamination that may seep into the groundwater.

7.3.3.3 Site Surface Drainages. To minimize the risk of construction-related activities causing contaminated surface water seepage into the groundwater, the following measures will be taken:

- Retention ponds and ditches for holding and transporting contaminated surface water will be lined with low permeability soils.
- Facilities for handling contaminated runoff water will be excavated when they are no longer needed and added to the disposal cell.

Groundwater quality will be monitored during all phases of construction (remediation).

7.3.3.4 Borrow Source. The potential for groundwater contamination at the clay borrow source area is minimal.

7.3.3.5 Waste Excavation, Handling, and Transportation. Excavation and removal of contaminant sources from the site will ultimately improve groundwater quality at the site, but the potential for degradation of groundwater quality exists during remedial actions. During excavation, handling, and transportation of contaminated materials, the disturbed areas will drain to lined retention ponds, and the water will be subsequently transported to the SWTP for treatment and off-site release.

7.3.3.6 Disposal Cell. During construction of the disposal cell, the waste surface will be graded so that it will drain to the edge of the emplaced waste. Precipitation that falls on the waste will seep through to the leachate collection and removal system (LCRS) and be diverted to the SWTP for treatment and release. The amount of water required to control dust will be reduced by utilizing a dust suppressant.

The basal liner of the disposal cell and the LCRS will prevent contaminated leachate from entering the groundwater. Groundwater will be monitored during and after site remedial activities.

7.3.3.7 Dewatering. Excavation and removal of contaminant sources from the Weldon Spring site will ultimately improve groundwater quality at the site, but the potential for degradation of groundwater quality exists during the remedial actions. During dewatering of contaminated materials, good engineering practices and mitigative measures will be employed to minimize the potential for groundwater contamination. Groundwater quality will be monitored during all phases of construction.

7.3.3.8 CSS Facility. Excavation and removal of contaminant sources from the Weldon Spring site will ultimately improve groundwater quality at the site, but the potential for degradation of groundwater quality exists during the remedial actions. During the CSS process, good engineering practices and mitigative measures will be employed to minimize the potential for groundwater contamination. Groundwater quality will be monitored during all phases of construction.

7.3.3.9 VIT Facility. No process-related waters are planned to be discharged prior to treatment at the SWTP; therefore, the VIT facility should have no impact on the WSS groundwater quality.

7.3.3.10 Additional Treatments. Remedial activities will take place in Building 434, or adjacent to the SWTP1, preventing releases that could potentially impact the groundwater.

7.3.3.11 Site Closure. Most site closure activities will involve the handling of clean materials; however, the impact of some site closure activities could cause leaching of contaminants into the groundwater. The impact of these activities is expected to be minimal, because of the short-term duration of site closure activities.

Drilling and completion of ground water monitoring wells may also impact groundwater quality; however, precautions will be taken to prevent the introduction of drilling fluids into the drillholes.

7.3.4 Protection of Workers

All WSSRAP remedial activities will be conducted in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed, as needed. Level "C" is expected to be the highest level of personal protection required for most work.

7.3.4.1 Construction Material Staging Area. All activities will be conducted in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed, as needed. Level "C" is expected to be the highest level of personal protection required during construction of the CMSA.

7.3.4.2 Site Roads. Construction of site roads and haul roads will require an estimated 10 person crew for a duration of two to three months. All activities will be conducted in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed as needed. Level "C" is expected to be the highest level of personal protection required for work on the site roads.

7.3.4.3 Site Surface Drainage. Construction of the site surface drainage system will require an estimated six person crew for a duration of 10 to 12 months spread throughout the period of disposal cell construction and waste placement. All activities will be conducted

in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed as needed. Level "C" is expected to be the highest level of personal protection required for construction of the site surface drainage system.

7.3.4.4 Borrow Source. Borrow operations will span a four year construction period. All activities will be conducted in accordance with WSSRAP Health and Safety Plans. Workers will use half-face masks for protection from blowing dust during periods of high winds. Continuous monitoring of the work environment and the use of standard protective equipment such as that routinely employed in similar earth works projects will be employed, as needed. Level "C" is expected to be the highest level of personal protection required for work at the borrow source area.

7.3.4.5 Waste Excavation, Handling, and Transportation. All activities will be conducted in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed as needed. Level "C" is expected to be the highest level of personal protection required for workers involved in excavation, handling, and transportation of materials, although level "B" may be required for some activities related to removal of sludge.

7.3.4.6 Disposal Cell. All disposal cell construction and operation activities will be conducted in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed as needed. Level "C" is expected to be the highest level of personal protective equipment required for personnel working within the cell area; under special conditions determined by the WSSRAP Health and Safety personnel, Level "B", personal protective equipment may be required.

7.3.4.7 Dewatering. All activities will be conducted in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed as needed. Level "B" is expected to be the highest level of personal protection required for work during dewatering of the sludge.

7.3.4.8 CSS Facility. It is estimated that 13 workers will be employed to operate and support the CSS treatment facility. All activities will be conducted in accordance with WSSRAP Health and Safety Plans. Continuous monitoring of the work environment and the use

of protective equipment will be employed as needed; air quality will be tracked on the interior of the facility through the use of breathing zone air samples for worker protection. Level "B" is expected to be the highest level of personal protection required for work at the CSS treatment facility.

7.3.4.9 VIT Facility. It is estimated that approximately 30 workers will be employed to operate and support the VIT facility. All activities associated with the VIT treatment process will be conducted in accordance with WSSRAP Health and Safety Plans. Continuous monitoring of the work environment and the use of protective equipment will be employed as needed; air quality will be tracked on the interior of the facility through the use of breathing zone air samples for worker protection. Level "B" is expected to be the highest level of personal protection required for work at the VIT facility.

7.3.4.10 Additional Treatments. Workers may be exposed to radiologically and chemically contaminated soils, liquids, sludges, and solids during waste handling, treatment, disposal or off-site removal. All activities will be conducted in accordance with WSS Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed as needed. Level "B" is expected to be the highest level of personal protection required.

7.3.4.11 Site Closure. All site closure activities will be conducted in accordance with WSSRAP Health and Safety Plans; continuous monitoring of the work environment and the use of protective equipment will be employed as needed. Level "C" is expected to be the highest level of personal protection required for site closure work.

7.3.5 Wildlife and Wildlife Habitat

Remediation of the WSS will result in the temporary disruption or elimination of wildlife habitat. Some fauna will move to other similar habitats located adjacent to the construction areas. Flora located within these areas will be destroyed. Flora and fauna surveys conducted at the site and within the borrow area have identified three State endangered species at the site, along with two State rare and one Federal candidate species at the borrow area. Upon completion of remedial activities, the site will be graded and revegetated with native or other appropriate species, as determined in consultation with State and Federal agencies and in

accordance with site closure design requirements. Migration and dispersion of plants and animals from the surrounding area will repopulate the site as the habitat recovers.

Remedial activities that require vehicles to operate along public highways and the haul roads may also increase the number of animals killed. This potential will be reduced by limiting truck traffic at dawn and after dusk, strict enforcement of safe speed limits, and conducting employee awareness programs.

7.3.5.1 Construction Material Staging Area. Construction of the new CMSA will result in the disruption of wildlife habitat on the site. After completion of remedial activities, the site will be graded and revegetated, as appropriate. Migration and dispersion of plants and animals from the surrounding area will repopulate the site.

7.3.5.2 Site Roads. Construction of the site roads and haul roads will result in the temporary disruption of wildlife habitat along these roads. After completion of remedial activities, the site will be graded and revegetated, as appropriate. Migration and dispersion of flora and fauna from the surrounding area will repopulate these locations.

7.3.5.3 Site Surface Drainage. Construction of the site surface drainage system will result in the temporary disruption of wildlife habitat on the site. After completion of remedial activities, the site will be graded and revegetated, as appropriate. Migration and dispersion of flora and fauna from the surrounding area will repopulate the site.

7.3.5.4 Borrow Source. The 160 acre clay borrow source area is covered with woodland/shrub and wetlands. During borrow operations, extreme care will be taken to protect the flora and fauna to the maximum extent possible. Fencing will be constructed to prevent animals from falling into excavations, and diversion ditches and sediment structures will be constructed to protect wetlands. Construction activities will be phased so that an area will be restored and revegetated as soon as excavation is complete.

Borrow operations along public highways and the dedicated haul road from the borrow source area will potentially increase the number of animals killed. The potential will be reduced by limiting truck traffic after dusk and by strict enforcement of safe speed limits.

The Missouri Department of Conservation plans to convert the clay borrow source area into a woodland/shrub/prairie grass habitat. After completion of remedial activities, the site will be graded and revegetated, as appropriate. Migration and dispersion of plants and animals from the surrounding area will repopulate the site.

7.3.5.5 Waste Excavation, Handling, and Transportation. Excavation of Frog Pond, Ash Pond, and the raffinate pits will eliminate all wetlands, aquatic habitats, plants, and animals in the area. After completion of remedial activities, the WSS will be graded and revegetated, as appropriate. Migration and dispersion of flora and fauna from the surrounding area will repopulate the site.

Excavation, handling, and transportation of soils will increase the potential for erosion. This could result in an increased sedimentation load in local streams and lakes that receive surface water runoff from the site. During excavation, handling, and transportation of soils, good engineering practices and mitigative measures will be employed to minimize surface water runoff and increased sedimentation to local surface waters, thus minimizing any impact on aquatic habitats.

7.3.5.6 Disposal Cell. Construction of the disposal cell, as well as the potential for an increase in erosion and sedimentation in local streams and lakes which receive drainage or runoff from the site, will have minimal or no direct impact on wildlife or wildlife habitat; however, the siting and presence of the disposal cell will permanently eliminate on-site aquatic habitats and species.

Installation of fencing or escape avenues, such as geonet ladders, will prevent the trapping of animals in ponds or other excavations during cell construction and waste placement.

A vegetation management program will be developed for the disposal cell area to prevent the establishment of large and deep-rooted vegetation that could compromise the integrity of the disposal cell.

7.3.5.7 Dewatering. No impact on wildlife or wildlife habitats are anticipated from the dewatering activities.

7.3.5.8 CSS Facility. The CSS treatment facility, will occupy approximately 1.5 acres located near the eastern edge of Raffinate Pit 3 for a period of four years. After waste processing has been completed, the facility will be dismantled. The site will be graded and revegetated, as appropriate. Migration and dispersion of flora and fauna from the surrounding area will repopulate the site.

7.3.5.9 VIT Facility. The VIT facility will occupy approximately 1.5 acres located near the eastern edge of Raffinate Pit 3 for a period of four years. The proposed plant site is currently maintained as a grassy area that provides minimal wildlife habitat. After waste processing has been completed, the VIT facility will be dismantled. The site will be graded and revegetated, as appropriate. Migration and dispersion of flora and fauna from the surrounding area will repopulate the site.

7.3.5.10 Additional Treatments. On-site treatment and disposal activities will be conducted in Building 434, at the SWTP1, and/or the CSS or VIT facilities; therefore, no impact to wildlife or wildlife habitat is anticipated.

7.3.5.11 Site Closure. Remediation of the WSS will result in the temporary disruption or elimination of wildlife habitat; however, no additional environmental impact on wildlife or wildlife habitats due to site closure activities is anticipated. Upon completion of remedial activities, the site will be graded and revegetated with native or appropriate species, as determined in consultation with the appropriate State and Federal agencies and in accordance with site closure design requirements. Following site closure, migration and dispersion of flora and fauna from the surrounding area will also act in repopulating the site as the community recovers.

7.3.6 Noise

Increased ambient noise levels due to operation of construction equipment will occur throughout the WSSRAP remediation activities. Equipment, including mufflers, will be maintained in good condition and will be periodically inspected to help control noise levels. Hearing protection may be required if noise levels exceed 80 dBA for an eight hour day, per OSHA regulations (29 CFR 1910.95).

7.3.6.1 Construction Material Staging Area. Increased ambient noise levels will occur due to operation of equipment during construction of the CMSA. The noise impact will be temporary and will cease following completion of construction and operation of the CMSA.

7.3.6.2 Site Roads. Increased ambient noise levels will occur during construction of the site roads and haul roads. Activities during construction of the haul road from the clay borrow source area will be timed to minimize interference with scheduled activities at Francis Howell High School.

7.3.6.3 Site Surface Drainage. Increased ambient noise levels will occur during construction of the site surface drainage system. Noise impacts will be temporary and will cease following completion of construction of the drainage system.

7.3.6.4 Borrow Source. Increased ambient noise levels will occur due to operation of equipment during borrow source operations. Activities during construction at the clay borrow source area will be timed to minimize interference with scheduled activities at Francis Howell High School.

7.3.6.5 Waste Excavation, Handling, and Transportation. Increased ambient noise levels will occur during excavation, handling, and transportation of soils. Noise impact will be temporary and will cease following completion of remedial activities.

7.3.6.6 Disposal Cell. Increased ambient noise levels will occur during construction of the disposal cell. Noise impact will be temporary and will cease following closure of the disposal cell.

7.3.6.7 Dewatering. Increased ambient noise levels will occur during dewatering activities. Noise impact will be temporary and will cease following completion of dewatering activities.

7.3.6.8 CSS Facility. Increased ambient noise levels will occur during construction and operation of the CSS treatment facility. Noise impact will be temporary and will cease following completion of CSS processing operations and plant dismantlement.

7.3.6.9 VIT Facility. Increased ambient noise levels will occur during construction and operation of the VIT facility. Noise impact will be temporary and will cease following completion of VIT treatment operations and plant dismantlement.

7.3.6.10 Additional Treatments. Increased ambient noise levels will occur during the alternative waste treatment activities. Noise impact will be temporary and will cease following completion of the activities.

7.3.6.11 Site Closures. Increased ambient noise levels will occur during site closure activities. Noise impact will be temporary and will cease following completion of site closure activities.

7.3.7 Resource Commitment

Aggregate and construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be consumed during site remedial activities. Adequate supplies of these materials are readily available at the site.

7.3.7.1 Construction Material Staging Area. Approximately 32,000 cu yd of aggregate and an undetermined quantity of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be consumed in construction of the CMSA. Adequate supplies of these materials are readily available in the WSS area. Following closure, some of the materials may be reused for road surfacing in locations such as the local wildlife areas.

7.3.7.2 Site Roads. Approximately 50,000 cu yd of aggregate and an undetermined quantity of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be consumed in construction of the site roads and the haul road from the clay borrow source area. Following closure, some of the materials may be reused for road surfacing in locations such as the local wildlife areas.

7.3.7.3 Site Surface Drainage. The WSSRAP will require approximately 2,300 cu yd of erosion protection materials and 25,000 cu yd of low permeability liner material for construction of the site surface drainage system. An undetermined quantity of construction

supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be consumed during construction activities.

7.3.7.4 Borrow Source. Approximately 3 million cu yd of borrow materials, including approximately 2.5 million cu yd of clay from the borrow source area will be consumed in WSSRAP remediation activities. An undetermined quantity of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be consumed in construction activities associated with the borrow operations.

7.3.7.5 Waste Excavation, Handling, and Transportation. Relatively small quantities of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be used during excavation, handling, and transportation of soils.

7.3.7.6 Disposal Cell. Clayey soils from the borrow source area; sand, gravel, and rocks from commercial sources; and geosynthetic materials, such as geotextile and flexible membrane liner materials will be used in construction of the disposal cell and temporary retention ponds.

7.3.7.7 Dewatering. Relatively small quantities of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will also be consumed by the dewatering activities.

7.3.7.8 CSS Facility. Approximately 89,000 tons of Portland cement and 135,000 tons of fly ash will be required for the CSS process. Relatively small quantities of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will also be consumed.

7.3.7.9 VIT Facility. Approximately 825 million cu ft of natural gas will be consumed in the VIT treatment process. Additional quantities of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be consumed.

7.3.7.10 Additional Treatments. Relatively small quantities of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will also be used during the treatment processes.

7.3.7.11 Site Closure. Relatively small quantities of construction supplies such as fossil fuels, rubber tires, construction equipment, electricity, and miscellaneous supplies will be consumed by the site closure activities.

7.4 Energy and Resource Conservation

The primary mission of the Weldon Spring Remedial Action Project is to protect human health and the environment; energy and resource conservation and process effectiveness are secondary, but nonetheless important, WSSRAP missions. Energy and resource conservation impacts have been given important consideration as a part of the total conceptual design of the disposal cell. Examples of the types of energy and resource conservation measures included whenever appropriate and practical include, but are not limited to, the following:

- Minimizing travel distances to conserve fossil fuels.
- Locating facilities in areas slated for removal activities, thereby conserving the amount of energy required for site preparation.
- Judicious use of fuel and electrical power in accomplishing tasks.
- Use of high-efficiency motors throughout the design of the disposal facility.
- A three month winter shutdown of activities.

7.4.1 Construction Materials Staging Area

The CMSA will be constructed at the north end of the site in a presently contaminated area near the disposal cell. Locating the CMSA in this area will accomplish the dual objective of minimizing both travel distances and site preparation.

7.4.2 Site Roads

Most new site roads to be designated as "dirty" will be constructed in contaminated areas that will require clearing and grubbing as part of the site cleanup activities. Clean roads through contaminated areas will require that the contamination be removed from these areas.

7.4.3 Site Surface Drainage

Gravity drainage, where applicable and practical, will be used to convey runoff to outfall locations, largely eliminating the necessity for pumping plants.

7.4.4 Borrow Source Area

Double handling of materials during the borrow area operations will be reduced to the maximum extent. When practical, materials will be transported directly from the clay borrow source area to the location of final placement. Proper surveillance during production of the borrow materials will minimize waste, thereby conserving energy and resources.

7.4.5 Waste Excavation, Handling, and Transportation

Most of the equipment used to excavate, handle, and transport materials and to construct support facilities will be diesel fuel operated. Procedures to reduce the diesel fuel consumption of the equipment will be considered. The subcontractors will be required to routinely maintain vehicles in good operating condition.

7.4.6 Dewatering

Energy conservation measures will be incorporated into the design and implementation of the dewatering activities to the extent practical.

7.4.7 Disposal Cell

Energy conservation measures to be implemented during disposal cell construction activities will focus on fuel conservation by methods such as minimizing travel distances and

quantities of construction materials used. Examples of conservation measures include the following:

- Optimization of the cell configuration (cell footprint area versus cell height) resulting in a truncated rather than a true pyramid shape. A small cell footprint reduces the quantities of construction materials required; the height limitation avoids less vertical travel by equipment during construction activities.
- The partially below grade disposal cell design utilizes excavated uncontaminated material as fill materials, thereby reducing the requirement for construction material. This design also minimizes the height of the disposal cell by utilizing the below-grade space created by excavation for the foundation as a part of the cell.
- The disposal cell design uses the clean-fill dike as part of the construction access ramp, thus avoiding additional construction activities and the use of additional materials.
- The disposal cell design maximizes the storage volume of the cell by reducing the basal liner and cover systems. This is accomplished by utilizing a geosynthetic clay liner and geotextiles in lieu of a conventional soil liner and drain/filter layer.
- The disposal cell design utilizes gravity drainage of leachate, thereby avoiding the necessity for pumping.

7.4.8 Site Closure

Energy conservation measures will be incorporated into the design and implementation of the site closure activities to the extent practical. Fuel and electric power will be used only to the extent necessary to accomplish the tasks.

7.5 Uncertainties and Contingencies

7.5.1 General

This section summarizes uncertainties and contingencies associated with the major elements of the conceptual design as well as the total program. The intent is to identify critically important areas where additional information is needed. Refer to Section 5 for details of each component of the design and its associated uncertainties and contingencies. MVE tables for Sections 5 and 6 outline the expected conditions, potential deviations, and their affect on the design. The following sections highlight six of the major uncertainties and contingencies associated with the WSS chemical plant conceptual design.

7.5.2 Quantity Estimates

The in-place material isopach, physical characteristics, and cleanup criteria are needed for each area; i.e., contaminated soils, foundations, stockpiles, sludge, surface water and vicinity properties. Most of this information has been identified through the remedial investigation and feasibility study phase of the project; however, additional characterization studies are planned and quarterly updates are performed by various departments at the site. Other materials quantities will remain as estimates until the actual remediation. Flexibility has been built into the remedial design to account for an increase or decrease in waste quantities for treatment and disposal cell placement. Specific areas of concern include the raffinate sludge, raffinate pit clay bottom, and stock piled materials.

7.5.3 Raffinate Sludge Dredging

The preferred alternative for the removal of the raffinate sludges is to use a barge-mounted cutter-head dredge to pump the materials as a slurry to the dewatering facility. Determining the effectiveness of the cutter-head dredge at removing the raffinate sludge will require some testing to answer the following questions:

- Will the dredge be capable of meeting the dewatering, site water treatment plant, CSS treatment facility needs?
- How will the water level and depth to sludge vary as the cutter head dredge operates?

- What range of percent solids can the dredge provide?
- Will there be wide ranges or rapid fluctuations in the percent solids?
- How well can the operator provide a consistent feed of raffinate sludge to the dewatering facility?
- How much down time can we expect from the dredge due to mechanical breakdown or obstructions caught in the cutter head?
- How stable are the berms?
- What are the minimum and maximum water requirements for equipment and emission control, specifically radon flux?
- Will the dredging operation significantly increase radon levels in the immediate vicinity?

The CSS pilot scale testing facility will collect this information and additional information, as needed, and the final design criteria will depend upon results of the CSS pilot scale testing.

7.5.4 Raffinate Pit Clay Bottom

The raffinate pit clay bottom is not expected to be characterized until the sludge and water have been removed. The moisture content of the clay bottom will then be assessed to ascertain whether additional stability measures are required to support equipment. An updated dike stability analysis will also be required. Soil samples will be collected prior to excavation to determine the extent of contaminate migration.

7.5.5 Stockpiled Material

The stockpiled material will consist of soil, sludge, metal, rubble, and containers of various sizes. Stockpiled as-built information identifying material types, sizes, quantities, and

storage configurations, e.g., stockpile height, slope, access; container sizes, stack height, slope access; weights will be required.

7.5.6 Additional Treatments

A number of waste materials have been identified and will continue to be identified through further characterization efforts. Such waste include:

RCRA waste stored in Building 434.

TSCA polychlorinated biphenyl (PCB) waste stored in Building 434.

Arsenic-contaminated wood.

Water treatment sludge.

Tributyl phosphate liquids contaminated with mercury and PCBs.

Bench-scale treatability testing of each waste will be conducted to develop optimum contaminate and reagent mixtures. The tests will identify how effective the process is at meeting specified performance standards.

7.5.7 Radon Emanation Studies

An extensive evaluation is being conducted to assess the potential release and control of Rn-222 from three proposed operations to remediate the raffinate sludge: (1) raffinate sludge dredging, (2) storage, (3) CSS production, and final disposal cell placement of the treated waste. Computer models will be selected or derived, and suitable calculations performed to adequately determine potential releases from each element of the process, and to assess Rn-222 concentration impacts at the source, site boundary, and critical receptors. Further laboratory tests will be conducted to compliment the existing information and data base. The CSS pilot scale testing facility will provide additional design data prior to full scale operation.

A critical analysis of routine Rn-222 concentration measurements at the site boundary and background locations will be made to derive an acceptable criteria for demonstrating compliance

to DOE's commitment to significantly control Rn-222 to the off-site environment. The results of the study will provide engineered controls, appropriate operating procedure recommendations, and effective process design recommendations to mitigate and manage estimated radon releases, and offer reasonable assurance of fulfilling DOE's commitment.

7.6 Other Appurtenances and Operations

This section describes additional assessments regarding security, telecommunications, computer equipment, provisions for handicapped, storm shelters, and acquisition of right-of-ways.

7.6.1 Site Security

Security interests at the WSSRAP differ from security interests at an operating facility with nuclear involvement. The WSSRAP is a remediation project and will be protected in accordance with DOE Order 5632.6, *Physical Protection of DOE Property and Unclassified Facilities*.

Threats to WSSRAP security involve the following possibilities:

- Criminal trespass.
- Theft.
- Presence of illegal items.
- Severe weather.
- Fire.
- Accidental radiological release.
- Bomb threat.
- Disgruntled present or former employee of the WSSRAP.
- Vandals.
- Sabotage (to disperse contaminants or discredit the U.S. Department of Energy (DOE) or its contractor).
- Contamination (chemical or radiological) of anyone on site.

7.6.1.1 Security Following Site Closure. Security of the site following closure will accomplish the following:

- Protection of the public.
- Protection of the cell cover from intruders such as local residents, hunters, off-road vehicles, firewood cutters, and curious persons; among others who frequent the area.
- Protection of the environment from accidental cell cover rupture by human or animal disturbance. Protection will continue until the site has time to return to its natural vegetative state.

The final layout of the site will require the following:

- Access for maintenance activities at the disposal cell.
- Access to monitoring points.
- Protection of monitoring wells and other monitoring stations that may be located around the cell.

Site closure includes securing the site with a chain-link security fence that will limit unauthorized public access to the cell. The security fence is designed to last for a minimum 30-year monitoring period. It will provide protection to the public by discouraging entrance to the site, thus preventing possible exposure to any leachate that may have collected in the sumps.

The site security fence may be located along the outside perimeter of the buffer zone with an access control gate located between the administration building and the new access control building. The fence will require special treatment at major drainages to ensure proper flows. Authorized personnel and vehicle access will be through a locked access control gate.

The design life of the fence should be at least 30 years, which would accommodate the transition period for the site to return to its natural vegetative state. The fence should be chain link and be a minimum of 6 ft high. The top should not have any barbed wire or any other sharp projections because deer may jump the fence.

It is recommended that signs be placed on the fence at approximately 100-ft intervals, warning intruders to keep out. Signs may read "KEEP OUT - RADIOACTIVE/HAZARDOUS

WASTE DISPOSAL FACILITY". An appropriate sign should also be placed at the highway entrance.

The final site layout for a CSS cell is presented in Figure 5.4-2; the layout for a VIT cell is presented in Figure 5.4-3.

7.6.1.2 Site Security Force (Guards). The security force maintained at the WSS shall be responsible for protecting all DOE property and interests against trespass and vandalism. Site facilities requiring ongoing security observation and inspection include the administration building and its contents, trailers, the RCRA storage facility (Building 434), water treatment plants, and perimeter fencelines.

All security guard personnel shall receive initial training pertaining to all aspects of site security described herein. This training shall be conducted by the site Security Supervisor prior to first duty shift, and all guards shall receive additional training as orders and duties change. This training shall be conducted on a quarterly basis, or more frequently, as required. A training form shall be signed by each guard and the instructor upon completion of each session.

The *Security Manual* will be updated, as needed, to include changing site activities. All security personnel shall be trained whenever new orders are issued or temporary activities are increased. This training shall be conducted by the Safety Department.

- The security supervisor shall be responsible for these training activities and the posting of DOE and site posters and memos.
- A written record of all training activities shall be maintained in the security contract files to include guard and instructor signatures.
- Meetings with the subcontract security officials shall be conducted on a regular basis. Meetings will be conducted on a monthly basis or as needed.
- All new employees and subcontractor personnel shall be advised of security requirements during site orientation.

7.6.1.3 Security During Off Hours. If an unusual occurrence takes place on-site after work hours, security guards shall contact members of the Safety Department. Guards shall use the off hours Emergency Call Sheet to contact Safety Department personnel by starting at the top of the list and proceeding downward until contact has been made. The Emergency Call Sheet includes members of the Radiation Protection Group. The Radiation Protection Group personnel shall be notified if off-site vehicles enter the Controlled Access area. Only police, fire, ambulance, or utility vehicles may be permitted into the controlled area. No personal vehicles are permitted without management approval.

The fire department will automatically be alerted by the alarm company if the fire alarm sounds in the administration building or in Building 434. The emergency telephone number 911 should be called if guards are in the building when the alarm sounds. The alarm service will automatically call the site security trailer if there are no guards in the administration building when the alarm sounds. The alarm company has been provided with an emergency call sheet. This call sheet has the main site phone number. Whenever the administration building guard covers the main guard shack, the site phone system shall be call forwarded to the main gate guard shack.

Police, ambulance or other outside agency shall be scanned before exiting the site. If an incident is life threatening, the ambulance may leave the site before scanning. A radiation technician shall respond to the hospital with monitoring equipment and scan the ambulance at the emergency room.

Guards shall notify Safety Department personnel or off-site emergency agencies for other occurrences such as trespassers on site, burglaries, severe storm damage, doors open on certain listed buildings, and large openings in the fence. Security guards and switch board operators shall be instructed on how to deal with a bomb threat. A bomb threat checklist shall be kept at the guard office and at the switchboard. If a bomb threat is received, the person receiving the call shall obtain as much information as possible and then notify the site Safety Manager or his designee. The Safety Department shall provide bomb threat training on an as-needed basis, or at a minimum, every six months. A bomb threat memo and instruction sheet is posted at all site phones.

7.6.1.4 U.S. Department of Energy. Security operations at the WSSRAP are routinely appraised by the DOE. The security force participates in emergency response drills

on an as needed basis, or three times per year. Security operations at the Weldon Spring site are upgraded on a regular basis for increased construction activities, open houses, and tours of the facility. Security coverage will be revised to meet DOE needs when operations increase.

7.6.2 Telecommunications

A security trailer is located inside the main site entrance and is staffed 24 hours a day. The main site security trailer has been permanently assigned a site walkie talkie. This radio is to be kept in the site security trailer.

7.6.2.1 Cellular Phone Operation. Guards will contact emergency services by using a mobile cellular phone equipped with a portable roof mount antenna to obtain maximum output. During business hours and weekend inspections, the mobile phone shall remain in a designated safety vehicle. If the main power source in the vehicle becomes disabled, the phone can be operated by using the cigarette lighter hook-up or the enclosed battery unit.

7.6.2.2 Pager. Evening and night shift guards stationed at the main gate office will be equipped with a pager. The pager can be activated by picking up the receiver of the phone outside the main gate. During the day shift, the pager should be turned off and kept in a safe location.

7.6.2.3 Field Emergency Notifications. When an emergency occurs in the field, contact with the Access Control Monitor will be made by the most expedient means possible. The Access Control Monitor shall immediately notify by radio the response team members. If the incident is severe in nature, the Emergency Management Team shall be notified by the Access Control Monitor. The Management Team shall assemble in Conference Room 1 in the administration building. Response team members shall also be present to assist the management team. A remote two-way radio station shall be available at this location.

7.6.3 Computer Equipment

Computer security responsibilities at the WSSRAP include DOE property and computer systems. The computer room shall be locked at all times. Only members of the Management of Information System, Project Controls, and Management departments should have access. The

guard is not to open the door for anyone, except the cleaning crew. The guard shall stay and monitor activities until the cleaning crew leaves, then lock the door.

7.6.4 Provision for Handicapped

Guardrails shall be erected whenever a walking surface changes elevation by more than 2 ft. Tape barricades may be used for this purpose, but such a barricade must be 5 ft from the change in elevation. All changes in elevation shall be marked with some kind of warning such as yellow and black tape or fluorescent orange paint. Handrails shall have smooth surfaces or be taped to prevent splinters. All wall openings shall be guarded. Where a door opens onto a platform, the width of the door shall not reduce the effective width of the platform to less than 20 in.

Runs and risers on all stairs shall be constructed in accordance with OSHA regulations. Ramps shall have a maximum angle of 7°.

Stairs leading to office and warehouse trailers shall be firmly anchored and equipped with handrails on both sides. Risers, including the top and bottom steps, shall be of equal height. Decks shall be labeled with their rated capacity.

Floor hole covers shall be labeled "WARNING - TEMPORARY COVER - DO NOT REMOVE OR STORE MATERIAL". Hole covers shall be cleated and constructed of 3/4-in. plywood with supports 18 in. on center or less.

7.6.5 Severe Weather Shelters

The Safety Department is responsible for issuing severe weather warnings to all other departments and outside work crews and for ensuring that adequate shelter is available, and is also responsible for issuing an "all clear" notice when the danger is past. Department heads and outside crew supervisors are responsible for ensuring that all personnel under their control are notified when severe weather warnings are issued and for ensuring that applicable severe weather procedures are followed.

The Safety Department shall place National Oceanic and Atmospheric Administration (NOAA) weather alert radios in specified areas that are always manned. The Safety Department

shall notify all departments that a severe weather watch is in effect, and that all personnel should be prepared to take appropriate action if the alert escalates to a severe weather warning. Outside construction personnel shall be instructed to organize their work so that operations can be quickly and safely shut down. All employees shall be informed of, and reminded about, shelter/take cover procedures. All personnel in open areas shall move to cover; crews in areas where local shelter is not available shall proceed to the Access Control (Building 410) for shelter.

In the event of tornado warnings, guards at the main site shall report to the administration building and take shelter in the center hallway near the restrooms. If time permits, all keys, walkie talkies, and flashlights shall be taken and kept with the guard.

7.6.6 Real Estate Issues

DOE requirements regarding real estate issues may be found in DOE Order 4300.1C, *Real Property Management*. This section identifies some of the real estate issues (easements, right-of-entry, licenses, permits) associated with the chemical plant site, vicinity properties, borrow source area, and borrow haul road development and operation.

7.6.6.1 Chemical Plant Site. The final design of the disposal cell will include a 300 ft buffer zone from the edge of the waste. There is potential that this requirement would necessitate acquisition of additional land adjacent to the chemical plant boundary. Following site closure, portions of the site outside the disposal cell and cell buffer zone could potentially be transferred to other organizations/agencies.

7.6.6.2 Borrow Source Area and Borrow Haul Road. The proposed borrow source area and borrow haul road corridor are located within the Weldon Spring Conservation Area, owned by the Missouri Department of Conservation (MDOC), as shown on Figure 5.1.7-4. Data gathering and planning for development of the borrow source area will require activities such as flora and fauna surveys, land surveys, soil borings, compaction test fill, vegetated cover test plot, archeological investigations, and other site activities. The Project Management Contractor (PMC) must obtain easements, right-of-entry, licenses or permits to gain access and use the property to perform some of these activities. In addition, the PMC must verify University of Missouri ownership and easements adjacent to the area, and coordinate with

the MDOC regarding MDOC and public access to adjacent areas during operation and final site conditions following reclamation.

7.6.6.3 Access of Utilities to the Borrow Area Site. Two options available to the PMC to provide utilities to the borrow area site include the PMC acquiring easements for utilities, or utility providers acquiring easements and providing utilities at the borrow area perimeter to the PMC.

7.6.6.4 Borrow Haul Road. The borrow haul road will require easements from the MDOC and coordination of an agreement with the Missouri State Highway Department (MSHD) for the State Route 94 crossing. Although utility easements exist along State Route 94, it will be necessary for the PMC to coordinate with all affected utilities (water, electric, and petroleum pipeline). If construction of the haul road includes realignment of State Route 94, additional coordination between the MSHD and the MDOC would be required. Realignment of State Route 94 would likely require access alteration for Francis Howell High School and St. Charles County Highway Maintenance Facility.

7.6.6.5 Other Activities. Other activities that may require easements or other real estate actions or notifications include the following:

- Army road restoration.
- Process sewer line removal associated with the Imhoff tank removal.
- Installation of monitoring wells or other monitoring devices on property not directly controlled by the DOE.
- Access to non-Superfund vicinity properties to conduct remedial activities that include, but are not limited to, access road construction and removal activities.

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8 CELL PERFORMANCE

8.1 General

This section describes how the disposal cell will perform during its design life. The various components of the disposal cell were identified, compared, and selected in previous sections. This section considers the cell components as a total system and assesses and describes the performance of the system. For a more detailed discussion of the procedures and considerations involved in evaluating disposal cell performance refer to Caldwell and Reith (1993) (Ref. 130). Table 8-1 lists the systems that impact cell performance and the factors that influence each system.

Only the performance of the disposal cell developed for the chemical stabilization/solidification (CSS) treatment option is discussed in this section. Data on the physical properties of the vitrified material upon which to base a performance assessment are not available at this time. If vitrification is selected as the preferred treatment alternative, the treated waste form should be analyzed to define the relevant physical characteristics.

The preferred cell configuration (Figure 8-1) is the basis of the following performance assessments. The performance of alternative cell features that are identified in other sections of the *Conceptual Design Report* (CDR) are also discussed and qualitatively assessed. The performance of alternatives eliminated in the modified value engineering (MVE) process was not considered. Figure 8-2 depicts the conceptual design cross section of the disposal cell.

The hydrologic performance evaluations, models, calculations, and alternative assessments discussed in this section are described in detail in *Supporting Study 45, Disposal Cell Performance Assessment* (in progress) (Ref. 129). Data developed from *Supporting Study 4B, Disposal Facility Hydrological Performance Monitoring* (in progress) (Ref. 103), provided the basis for assessing hydrological performance monitoring needs. The conceptual designs developed based on data assessments for surface water control, erosion potential, slope stability, and settlement are presented in Sections 5.1.8 and 6.1.8. Assessment of long-term stability performance was supported by a geomorphologic assessment (Ref. 131).

8.2 Time Frames

Figure 8-3 shows the periods for which the performance of the disposal cell is assessed and described. These periods range from the construction period through the short-, medium-, long-, and very long-term time frames.

8.3 Systems Engineering Approach

The disposal cell performance assessment is based on an analysis of conceptual models developed for the cell, both as a total system and for specific components. For example, the cover component may be modeled as subcomponents of layers of different permeability. Precipitation on the cover runs off, is evapotranspired, drains laterally, or seeps through the layers and infiltrates the cell. Standard equations for flow through porous media and proven computer codes may be used to model the cover and to calculate the amount of infiltration to the wastes. The cover itself is one component of the entire disposal cell system, which includes the waste, the liner, and the leachate collection systems. By using calculated performance values that measure the cover's effectiveness in retarding infiltration as input to other component models, the performance of the entire disposal cell may be defined.

Figure 8-2 shows a cross section of the disposal cell. The wastes are encapsulated by double composite basal liners with leachate collection and removal systems (LCRS), the clean-fill dikes, and the top cover. The most significant environmental forces affecting the performance of the cell and its foundation are:

- Precipitation and the resulting surface runoff that may erode the cell or the landform surrounding the cell.
- Water infiltrating through the cover to form leachate in the wastes, and exiting from the basal drains.
- Wind forces caused by tornados crossing the surface of the disposal cell.
- Static (gravity) and dynamic (earthquake) forces that affect cell and waste stability.

- Deformation of the cell, including waste subsidence, and total and differential settlement of the foundation, waste, and containment systems.
- Thermal and radioactive emissions from the wastes.
- Geomorphologic affects on the disposal cell.
- Biointrusion from vegetation, animals, and humans.

Cell performance is described in terms of the four major cell systems: hydrology, stability, emissions (other than seepage), and biology (Table 8-1).

8.4 Regulatory Framework

The potential applicable and/or relevant and appropriate requirements (ARARs) and design guidelines discussed in Section 4 establish the disposal cell performance requirements, goals, and objectives. These guidelines dictate that the cell perform for 1,000 years, to the extent reasonably achievable and, for at least 200 years to prevent dispersal of the wastes; to control radon flux; to deter human, animal, and plant intrusion; and to limit seepage that may adversely affect the surface water or groundwater.

8.5 Disposal Cell Performance

8.5.1 Hydrology

8.5.1.1 Flows and Fluxes. Hydrology includes all aspects of cell performance that involve the flow or seepage of water and potential contaminants into, through, and from the cell. Hydrologic assessments were performed using the U.S. Environmental Protection Agency's (EPA) *Hydrologic Evaluation of Landfill Performance* (HELP) model computer code. This model uses a water balance approach to determine the vertical upward, downward, and lateral fluxes and flows that take place through and from the multilayered disposal cell system. HELP considers climate (evapotranspiration and precipitation), vegetation (ground cover based on a leaf area index), and the material properties of the layers being modeled. It couples several one-dimensional flow models and balances the amount of water or moisture occurring across layer boundaries.

For the vegetated top slope of the cover, the surface runoff routes and flow rates that have been considered (Ref. 129) are shown in Figure 8-4 and Table 8-2, respectively. Potential routes include precipitation, evapotranspiration, runoff, cover drain, cover infiltration, seepage through the waste, flow to the leachate collection system, and seepage through the liner.

The results of the individual assessments are combined to assess the overall performance of the cell for the time periods discussed in Section 8.2. Table 8-2 demonstrates that the cover effectively limits infiltration into the waste. Steady-state seepage conditions in the cover cause infiltration into the waste to be less than 1 gallon per acre per day (gpad). The vegetation is one of the primary performance features that limits infiltration. In the very long term, the cover controls the rate and amount of moisture moving through the waste and into leachate collection system or exiting from the bottom of the cell.

Normal rainfall and evapotranspiration near the surface of the cell are each several thousand gpad, and runoff is several hundred gpad. The resulting infiltration and ultimate seepage from the cell is very small (less than 1 gpad) by comparison.

Any lateral flow in the LCRS is the result of ponding on the flexible membrane liner (FML). During construction (short term), precipitation on the waste and directly on the LCRS prior to waste placement may cause large, but rapidly decreasing, lateral flows. Modeling results show that once the cell is completed, seepage from the waste eventually approaches equilibrium with infiltration through the cover, and lateral drainage continues to decrease.

During cell construction, before the cover is placed, and until near equilibrium moisture conditions are reached in the cell, the liner/leachate collection system prevents leachate from leaving the cell and migrating to the groundwater. However, once placement of low-permeability waste begins, leachate carried by the LCRS is reduced from high values (up to 2,500 gpad; Table 8-2) during construction to small quantities (less than 2 gpad) in the long term. Thus, drainage from the LCRS should decrease during construction.

The moisture content of the waste is expected to exceed equilibrium with field capacity when it is placed, thus water should begin to drain at a slow rate immediately after placement. The rate and amount of drainage into the leachate collection system are determined by the physical properties and moisture content of the waste. Conservative initial moisture conditions (saturation) have been assumed for the cell performance analysis, because little data have been

collected regarding waste drainage characteristics. It is likely that the actual seepage from the waste will be less than predicted, because the initial waste moisture content assumed in the model may be greater than the content initially present in the cell. If necessary, the seepage from the waste could be accelerated by changing the drainage characteristics of the waste. Final design will provide more detailed evaluations.

Seepage from the base of the cell is expected to begin after 200 years, partially due to degradation of the FML. Analysis of the system indicates that seepage from the disposal cell should not vary a great deal, regardless of the performance period. The waste should drain at a very slow rate, and should not achieve steady state until well after 1,000 years. This effect is illustrated in Table 8-2, which shows that seepage from the waste exceeds cover infiltration for the entire 1,000 years. Most of this seepage is transmitted laterally in the drain. Drainage from the base of the cell is controlled by the bottom engineered fill, which forms the clay component of the composite liner, and should not occur for several hundred years. This is a reasonable assumption because composite liners are very effective as seepage barriers. It should be noted that the hydrologic modeling did not take into account consolidation effects and any drainage that may be associated with this phenomenon.

Flow pathways depicting seepage and runoff for the perimeter clean-fill dikes are shown on Figure 8-5. Due to model limitations, the rock-covered slope cannot be evaluated quantitatively. Models currently available cannot evaluate evaporation through a rock cover. However, infiltration that may occur in this area will not impact cell performance because no waste will be placed under this portion of the cell. For the same reasons, seepage into the alternative vegetated side slope cover was not evaluated.

8.5.1.2 Geochemistry. This section describes the quality of transient and steady-state seepage from the different waste forms, the interaction of this seepage with the soils through which it flows, and impacts on soil chemistry and mineralogy. Development of a site-specific geochemical profile for the disposal cell is being supported by a series of experiments on the Weldon Spring site wastes, which are being conducted at Pacific Northwest Laboratory (PNL). These experiments, which are briefly summarized in the following section, should be completed by the end of 1993.

The data generated at PNL will be used to model the performance of the disposal cell with respect to contaminant retention and the potential effects of migrating leachate on soils within

the vadose zone and the water-table aquifer, in the event that the liner or foundation engineering controls are no longer functional. Two U.S. Environmental Protection Agency computer codes will be used for this modeling: MINTEQA (1991), which is a geochemical code that models equilibrium and sorption reactions, and CHEMFLO (1989), which is a one-dimensional water and chemical transport code that models movement through the unsaturated (vadose) zone. Other EPA and U.S. Geological Survey (USGS) computer models may be used if necessary.

Various wastes will be placed in the disposal cell. Some wastes will be processed with cement and fly ash or fly ash alone prior to placement into the cell. Leachate that evolves from the treated wastes will be a function of the chemistry of infiltrating water, the composition of the waste form, and the sequence of wastes through which the leachate passes. The strongest effect on leachate arriving at the basal drains will be the composition of the last waste form leached, whereas the weakest effect will be the initial composition of the infiltrating water. Because wastes will most likely be layered into the cell (Section 5.8.6 Waste Placement), the basal layer, a soil with low levels of contamination, will have the greatest influence on leachate compositions as long as preferred pathways through this layer do not develop. The PNL studies include an investigation of the interaction of leachates from the CSS treated waste forms with contaminated site soil.

To characterize the leachates that could potentially evolve from the major waste forms, a series of batch tests are being conducted at PNL. Batch tests involve equilibrating a measured amount of a solid (waste material in this case) with a measured amount of liquid. The composition of the initial solid and the equilibrium solution or leachate will be determined as part of these tests. This information will be used to define the leachability of the various waste forms under the expected cell conditions and will provide site-specific data for the purposes of geochemical modeling. If unacceptable levels of any contaminant are found in the leachates, the contaminant will be further evaluated to determine if the CSS process could be modified to retain the compound. Additional experiments may be run on these modified waste forms. Batch leach tests will be performed at PNL for the following waste forms: cement/fly ash-stabilized sludge, cement/fly ash-stabilized sludge plus nitroaromatic-contaminated soil, fly ash-stabilized contaminated soil, and contaminated soil.

An additional test will be conducted to determine the buffering capacity of the treated waste forms. The retention of many contaminants is highly dependent on the maintenance of a highly alkaline system. This test will examine the volume of soil water, which has a pH near 6,

required to lower the pH of the leachates from 10, the expected initial value of the treated waste, to a value of 7. The results of this leach test, coupled with the infiltration calculations discussed in Section 8.5.1.1, will provide some constraint on the length of time a waste form will effectively immobilize pH-dependant contaminants.

Although the results of these experiments will not be available until late 1993, the general behavior of the contaminants of concern can be estimated based on similar experiments conducted at PNL (Ref. 132), thermodynamic data, geochemical models, and toxicity characteristic leaching procedure (TCLP) data collected by the Project Management Contractor (PMC). Nitrate should be mobile and should be present in the leachate at high levels until most of the nitrate has been removed from the waste forms. Immediately after placement of waste in the cell, when nitrate levels are expected to be the highest, leachates will be collected and treated to remove nitrate and other contaminants of concern. Sulfate and uranium should be immobile. Molybdenum, is mobile at high pH values, but should precipitate in soil layers, which have the capacity to lower the pH to a less alkaline value. The behavior of arsenic and the nitroaromatic compounds is not predictable. TCLP results indicate that these species may not be strongly retained within the treated waste forms. Thermodynamic data indicate that arsenic, which forms anionic complexes at high pH values, should be mobile. If the results of the PNL study indicate this to be the case, cement/fly ash or fly ash mixes amended with additives, such as activated carbon or possibly zeolites, may be tested to determine if retention is significantly improved for wastes containing high levels of these compounds. Alternatively, a geochemical attenuation layer amended with these or other additives may be considered for drain outlets and adjacent low-lying areas of the cell where leachate may collect in the long to very long term. Prototypes for engineered sorbent barriers have been evaluated at PNL and were found to be effective in removing organic compounds and anionic complexes similar to those formed by arsenic (Ref. 133).

The PNL work will examine the interaction of the most concentrated or "worst-case" leachate with the clay liner soil and two foundation soils: the Ferrelview Formation and the clay till. This work will examine the mineralogy of the soils, attenuation of contaminants by these soils, and changes in total leachate chemistry. These experiments will provide the site-specific distribution coefficients (K_d s) for use in geochemical modeling of the liner soil-leachate system and transport through the vadose zone. Since changes in the mineralogy of the clay liner soil may detrimentally affect the porosity of this layer, the reaction with the leachate will be

examined to evaluate the potential precipitation of calcium/magnesium minerals in the clay liner layer.

Batch leachate tests conducted by the USGS (Ref. 76) on Ferrelview Formation soils and clay till indicate that the Ferrelview Formation soils readily sorbs uranium within the pH range of 7 to 9. Although the soil solutions used for the USGS experiments differ from the waste leachate solutions, the capacity for uranium attenuation is expected to remain high in this unit.

8.5.2 Stability

Cell performance against natural forces including water runoff (erosion), gravity (settlement/consolidation and slope stability), geomorphology (geologic change), and wind forces (tornados) is addressed below.

8.5.2.1 Erosion. The disposal cell has been designed to resist runoff from a probable maximum precipitation (PMP) event occurring directly over the disposal cell (Section 5.2.7). The cell is also above the maximum elevations of a probable maximum flood (PMF) for any drainage outside the cell footprint. Since PMP and PMF events are larger than what is expected to occur during the disposal cell design life, the disposal cell should resist erosion indefinitely, providing there is no deterioration in materials or disruption of protective layers or vegetation.

The top cover has been designed to resist rilling from sheet flow, gullyng from concentrated flows, or erosion that might be caused by runoff from the PMP (Section 5.2.7). The gravelly soil selected for the uppermost cover component also resists erosion. With time, a more erosion-resistant gravel veneer may develop. A vigorous plant community should gradually thicken the cover by adding biological material to the soil. Soil loss caused by transport of fine particles in overland flow counters this phenomenon.

In the event that vegetated soil is selected as the side slope cover detail, some erosion over time is possible. Vegetated soil on the side slopes can endure 30% to 40% of the PMF without incurring significant damage (Ref. 134). However, the vegetated side slope will not resist a PMF. Figure 8-6 shows erosion models for a soil clean-fill dike. Face retreat or slope flattening of the soil dike may occur, depending on geomorphic changes of the surrounding area.

During placement of waste in the disposal cell, run-on from the area will be prevented by the clean-fill dikes, which will be constructed first. Runoff from the waste will be collected and pumped to the site water treatment plant. Sediment contained in the runoff will settle in a small detention pond near the cell. When one cell construction phase is completed, a temporary soil cover, comprising the lower portion of the radon barrier, will be placed over the cell, and temporary erosion control measures, such as straw crimped into the surface, will be applied. Further details of the construction storm water controls and the temporary cover for completed phases of the disposal cell are found in Sections 5.2.6 and 5.2.7, respectively.

8.5.2.2 Slope Stability. The stability of the disposal cell has been considered in the conceptual design. Stability is enhanced by the use of clean-fill dikes with relatively flat (5H:1V) side slopes. Creep in the soil slope is eliminated by using compacted soils and by excluding organic or expansive soils. Buildup of water and seepage forces have been considered in the slope stability analyses and are generally eliminated by the design. Analyses included consideration of stability during an earthquake, which is the most significant environmental force that could affect slope stability. The design earthquake is a maximum credible event (MCE) of 0.26 g acceleration. This design parameter was selected based on a detailed site-specific earthquake study (Ref. 19) and is unlikely to be exceeded during the design life of the disposal cell.

Based on the geometry of the disposal cell, the minimum factor of safety against a deep-seated failure is greater than 4, well above the minimum acceptable factor of safety of 1.5. This failure surface resides entirely within the clean-fill dike and does not penetrate the waste. The factor of safety for the clean-fill dike side slope configuration under seismic loading was not analyzed directly. Originally, a cell up to 74 ft high with waste placed under the slope was evaluated and found stable (Ref. 134). Because this configuration yields lower static safety factors than the clean-fill dike configuration, it is logical to assume that the seismic loading safety factor for the clean-fill dike would be greater. The stability of the clean-fill dike configuration will be assessed during final design.

8.5.2.3 Deformation. Settlement of the cell foundation or the waste may lead to deformation of the cover. The loading imposed by the disposal cell will cause settlement of the foundation. These deformations have been considered in the conceptual design (Section 5.2.4). To minimize the potential for cover deformation due to waste subsidence, the waste materials from the Weldon Spring site will be carefully placed and, if appropriate, compacted to reduce

settlement, eliminate voids, and prevent subsidence. Up to 50% of the waste to be placed in the cell will have been stabilized with a mixture of cement and fly ash that is stronger than the soils that will form the protective coverings over the waste.

The disposal cell is designed to accommodate up to 2 ft of settlement in the soil foundation. The leachate collection systems and cover drain, as well as the top slope surface, are all sloped so that positive drainage will be maintained through completion of settlement.

The loading imposed by the disposal cell is not sufficient to cause dissolution of the bedrock.

8.5.2.4 Geomorphology. In general, the disposal cell is located in a stable area, away from areas prone to sudden landform alteration by natural forces (Ref. 131). Being at the top of a topographic divide, the area is considered a zone of fluvial erosion. However, the clayey soils minimize the rate of and potential for this process. Flooding is not possible because of the upland location; vegetation will preclude wind erosion, and mass wasting is not a potential due to the favorable site topography and bedrock depth. Solutioning of the underlying limestone bedrock is an active geomorphological process in the region. Site specific studies show that there is no evidence of sufficiently developed solution features in the disposal cell area to cause concern over the project design life.

The area surrounding the cell will be contoured to control long-term flow and geomorphologic change that could detrimentally affect the integrity of the disposal cell. In particular, the site will be contoured to prevent the development of gullies that could migrate headward to the cell. Vegetation, similar to the climax communities proposed for the cell cover, will extend across the surrounding ground surface, although trees may be included in this zone. Geomorphologic studies are underway to assess the long-term behavior of the site relative to the landform present (Ref. 131). This study has identified that the only geomorphologic hazard to the disposal cell is fluvial erosion (gullying).

Placing a thickened riprap toe apron around the critical portions of the cell (Sections 5.1.6 and 5.2.7) will prevent gully headcutting and lateral migration of existing channels from impacting the cell. Another form of protection is the rock check dams that may be located a distance from the cell along the existing drainages. Additional protection can also be gained by grading slopes to minimize flow velocities, maintaining surface water drainage areas and flow patterns similar to pre-chemical plant patterns, minimizing concentrations of runoff near the cell

toe, and modifying the landscape. Landscape modification includes reestablishing preexisting stream patterns, stream gradients, and drainage densities to the maximum extent possible. Another objective of landscape modification is to reduce or eliminate flow off the cell from entering the Southeast Drainage.

8.5.2.5 Wind Impact. Studies performed to evaluate the ability of the completed disposal cell to withstand severe weather or tornados indicate that little or no damage would be sustained (Ref. 137). Any damage would be surficial in nature (disruption of cover materials) and would be repaired as a cell maintenance function.

8.5.3 Emissions

8.5.3.1 Radon Emissions. The RAECOM computer program calculates surface fluxes and radon barrier thickness requirements for the top cover. *Supporting Study No. 19A, Radon Barrier Evaluation* (in progress) (Ref. 72), presents a detailed analysis that shows that the radon barrier thickness of 3 ft will effectively attenuate radon and reduce surface flux to below the standard of 20 pCi/m². In addition to the standard clay radon barrier, the cover incorporates a geosynthetic clay liner (geomat) of bentonite as an infiltration barrier component. The bentonite alone will attenuate the predicted radon flux from the wastes. The FML will also serve as an effective radon barrier for as long as it remains intact. In effect, the cell cover has a triple, or redundant, radon barrier system.

The design analysis will be repeated as additional data are developed and refined for waste radon emanation and diffusion and waste soil moisture retention characteristics. A final cover thickness will be verified by testing the source term during waste placement.

Cover cracking or imperfections in the placement of the clay radon barrier will not lead to excess radon flux, because the bentonite-containing geomat will perform as the effective radon barrier. In addition, there are other layers within the disposal cell cover, such as the drains, the biointrusion barrier, the rooting media, the geosynthetic clay liner and the FML that will, to some extent, attenuate radon that might emanate from the waste. In addition, the conceptual design does not account for the attenuative capacity of the cover.

There will be minimal radon flux through the clean-fill dikes because the soils and shear bulk of the dikes will effectively attenuate radon fluxes through the dikes. In addition, a zone of low-

permeability compacted clay, which forms part of the composite liner, will serve as the radon barrier for the clean-fill dikes.

There is a potential for radon movement from the cell through the leachate collection system. *Supporting Study 35A, Phase I Status Report Assessment of Radon Release from Leachate Collection System* (in progress) (Ref. 135), assessed the potential for radon migration. The principal radon migration pathway in the leachate collection system is diffusion through the sand and gravel drain layers and the collection pipe network. Calculations have estimated that only a limited source volume in the vicinity of an exit pipe penetrating the clean-fill dikes contributes to potential radon releases, and the distance that the enclosed piping extends under the clean-fill dikes is sufficient to allow radon decay before it escapes from the cell. This issue will be further quantified during final design. A mitigative design feature consists of an FML placed between the waste and the leachate collection drain layers at the point where the exit pipes penetrate the clean-fill dikes. This feature would provide a sufficient linear distance between the radon source and the drain outlets to effectively attenuate the radon emitted from the stabilized waste before it reaches the exit pipe. Other methods of removing radon from the system involve the use of activated carbon filters or radon diffusion columns installed at the outlet of the LCRS.

There is a slight potential that radon will dissolve in the leachate and be transported into the leachate collection sumps. The quantity would be small because, after cell closure, the total drainage from the cell is expected to be less than 1 gpad (Section 8.5.1). Further data collection and quantification are required to assess this potential. Activated carbon filter systems, and/or sealed collection tanks, would mitigate the potential for uncontrolled release by either direct radon adsorption or by retaining the radon-laden air and water to permit natural radioactive decay in a controlled environment.

8.5.3.2 Thermal Emissions. The setting of cement/fly ash-stabilized waste materials, may generate heat that could affect cell component behavior. If the rate of placement of CSS material is sufficiently rapid, the heat of hydration will not dissipate before the next lift is placed. Should this occur, the thermal emissions could affect the cover by causing drying and cracking of the radon barrier, reducing infiltration, and potentially increasing vegetative growth. The planned rate of placement should be sufficiently low to prevent this from occurring. Other potential impacts include softening of the FML liners, and reduction of the clay/FML interface friction during waste placement.

8.5.4 Biology

Cell performance related to its interaction with vegetation, animals, and humans is assessed below.

8.5.4.1 Vegetation. Vegetation will enhance cell cover performance by limiting infiltration and providing erosion protection. Other sections discuss in detail the impact of vegetation on erosion and evapotranspiration (Sections 8.6 and 8.5).

On the top slope, a native grassland will be established in the gravelly soil of the upper cover component. The precise combination of soil and vegetation that performs best at the site will be established in test covers. These test plots will be constructed on site and monitored prior to placement of the final cover. A grassland community has been selected because, with the proper soil placement, grasses can be encouraged to produce a shallow but vigorous network of fibrous roots. Such a grassland community will often exclude deep-rooted plants by ecological competition. For instance, grasses in humid climates often completely cover the soil, limiting the opportunities for seeds from woody species to embed, germinate, or establish. The extraction of water from the shallow rooting zone may be so complete that no water remains for germinating woody species or for supporting deeper-rooted species.

Monitored natural burns or intentional scorching will maintain the competitive balance in favor of the native grassland community over invading woodland or forest communities. Infrequent mowing is an alternative to scorching. It is expected that mowing or scorching will be the only maintenance requirement for a native grassland on the cover. Section 8.6.1.2 discusses probable results once maintenance is discontinued.

8.5.4.2 Animal Intrusion. The biointrusion barrier in the top cover impedes the progress of burrowing animals. Rock on the side slopes effectively deters burrowing by animals; however, precise quantification of potential burrowing is not possible. It is believed that, should some burrowing occur, the thick cover (>8 ft) will prevent access to the waste. If burrowing occurs, an increase in infiltration could occur, but the affected area would be small compared to the total cell area. Therefore, little impact on hydrologic performance is expected.

8.5.4.3 Human Intrusion. Inadvertent and, to an extent, deliberate human intrusion is prevented by the design configuration and components of the cover and the dikes. However,

if an intruder desires to invade the cell, the thick cover and clean-fill dikes will deter, but likely not stop, such attempts. Signing and control by fencing will be required for as long as possible.

8.5.5 Data Needs

The analyses performed for the disposal cell performance assessment identified several items requiring further study during final design. These include:

- Additional waste characterization, including soil moisture retention characteristics and saturated hydraulic conductivity, so that the waste drainage characteristics can be modeled more accurately.
- Thermal characteristics of the CSS-treated waste, which will be developed during the pilot-plant operation, including the specific heat of hydration.
- Site-specific vegetation behavior developed from the cover test plots should allow a better understanding of the evapotranspiration of the cover.
- Geochemical tests, which are currently being conducted by PNL.

Additional assessments are required for final design. These studies are necessary because of design changes that are likely to occur during this process.

- Analysis of seepage through the cell based on data collected for the waste material.
- Evaluation of the geochemical characteristics and attenuative capacity of the site soils.
- Analysis of the fate of seepage that leaves the bottom of the cell.
- Analysis of the slope stability of the disposal cell based on the final selected slope geometry.
- Analysis of the potential deformation of the waste and the disposal cell and resulting strains caused by a maximum credible earthquake event.

8.6 Failure Scenarios

8.6.1 Design Considerations

8.6.1.1 General. This section describes cell system failure scenarios associated with the hydrologic and geochemical performance of the cell that may be reasonably postulated and analyzed. The failure scenarios postulated (for external physical forces and internal material behavior) are outside the range used to evaluate cell performance that could potentially alter the intended performance of the disposal cell. None of the hydrologic or geochemical failure scenarios presented in this report result in a catastrophic event, although some temporary negative environmental impact may occur. This is achieved by incorporating redundant and conservatively protective components in the cell design. These failure scenarios are not intended to be a risk assessment for the disposal cell. Rather, these scenarios serve as a basis for discussing and quantifying potential performance.

8.6.1.2 Hydrology. Cover failure scenarios that would increase the infiltration through the cover include cracking or biointrusion of the infiltration barrier system, increase in soil permeability due to freezing and thawing, loss of vegetation and associated evapotranspiration, cover FML deterioration, cover drain deterioration, and erosion of the upper layers.

Biointrusion, consisting of unwanted deep-rooted plants invading the cover or burrowing animals, could compromise the infiltration barrier. Both are discouraged by the biointrusion barrier. Invasion by unwanted plant species is also discouraged by planting a shallow-rooted climax species for cover vegetation. In addition, the cover will be monitored and maintained for as long as possible following completion. This redundant system, consisting of climax vegetation and a biointrusion barrier, greatly reduces the potential for compromise of the radon/infiltration barrier, which is itself a thick, difficult-to-penetrate, medium- to high-plasticity clay layer.

If the radon barrier were penetrated by an animal, burrow castings would expose contaminated waste on the surface. If a deep-rooted plant were to penetrate the waste, it could topple and expose contamination or provide preferential pathways for radon and moisture migration. If either situation resulted in full penetration of the radon/infiltration barrier, the infiltration rate through the cover would increase. The biointrusion layer is designed to resist such penetrations, but it is impossible to ensure that the problem will be eliminated by these

features. However, because of the thick cover, the probability of these processes causing infiltration barrier failure is remote.

Cracking of the infiltration barrier could result from subsidence due to differential settlement caused by unexpected deterioration in the waste or from the drying of the medium- to high-plasticity clays. This failure scenario is considered a remote possibility, because the relatively deep location of the radon/infiltration barrier within the cover reduces the potential for drying, and the high degree of control over waste placement limits differential settlement. Cracks that penetrate the active zone of the upper portions of the cover will be closed by freezing and thawing, so that a direct open conduit capable of carrying large quantities of water is unavailable for extended periods. Vegetation would respond to increased moisture in the soil with increased growth and resulting transpiration. As a result, infiltration into the cover drain layer will remain near 300 to 500 gpad. Nearly all of this infiltrating water will be removed by the drain, even if the radon and infiltration barrier has cracked and the geomembrane has deteriorated. Water that penetrates the radon barrier through a crack would also have to pass through approximately 40 ft of low-permeability wastes. Ultimately, this seepage would be removed in the leachate collection system.

An increase in cover permeability caused by freezing and thawing is improbable. The depth of the infiltration barrier is between 5.5 ft and 8.5 ft. Frost depth, which is discussed in Section 8.6, is much shallower.

Total loss of vegetative cover for a significant period of time due to natural causes is unlikely. However, the quality of the vegetation may deteriorate after maintenance ceases. If vegetation were lost, however, evapotranspiration would be reduced until the vegetation reestablished itself. This scenario was quantified in *Supporting Study 45, Disposal Cell Performance Assessment* (in progress) (Ref. 129), by reducing the leaf area index to a value slightly greater than bare soil. The result is increased surface runoff, but the amount of infiltration should not be affected because of the redundant infiltration barrier.

If the lateral drainage capacity of the cover drain layer, which lies directly above the infiltration barrier, is reduced, the head in the infiltration barrier would increase until lateral flow occurred in the overlying layer, the biointrusion barrier. This high-permeability biointrusion layer is capable of draining any water entering it. The resulting head buildup would increase the infiltration through the radon and infiltration barrier (assuming the FML has

deteriorated), and the moisture and the resulting moisture flux through the waste would begin to increase. However, due to the low permeability of the waste, equilibrium moisture contents would take hundreds of years to reestablish in the waste, with no net increase in seepage from the waste being experienced for hundreds of years due to the low hydraulic conductivities. If the FML does not deteriorate, then the increased head has little effect on infiltration through the cover.

Analyses also show that deterioration of the FML will result in a maximum increase in infiltration of 0.2 gpad. This would not occur until the long term and is considered in the normal cover operation (Section 8.5).

Failure of the LCRS may be caused by clogging and reduced flow capacity in the drains or by loss of the impermeability of the supporting liners. Progressive failure due to deterioration of the liners is accounted for in the normal operation of the disposal cell during the long and very long term by assuming that no FML liner is present. Collapse or clogging of the drains is discussed below.

Clogging may cause the LCRS drains to fail (either or both the upper and the lower, redundant LCRS drain). If one of the multiple outlet drains through the clean-fill dike clogs, a saturated zone may develop in the waste at the lower part of the affected "bay" as shown in Figure 8-7. Overflow into the other drainage bays will occur when the leachate surface reaches the divide between bays. Due to the relatively low drainage rates (Table 8-2), such a buildup of head in the waste will occur slowly and will not significantly affect cell performance since the head on each LCRS (a major factor in determining seepage through the liners) will not exceed several feet.

Each collection pipe will be surrounded by a zone of gravel, which is surrounded by high-density polyethylene (HDPE) liner material where the pipes extend through the base of the clean-fill dike, at the northern part of the cell. If the increased head causes the cell liners to leak at the point of the pipe penetration, this zone will perform as a high-permeability drain through which seepage may continue to migrate out of the cell. This reduces the potential for buildup of a saturated zone in the waste. In the unlikely event that this zone of gravel clogs, the state of equilibrium illustrated in Figure 8-7 will develop. Even if ponding occurs in one of the drainage bays, the resulting head will not increase the seepage from the cell to more than 1 gpad in the area of ponding. The remainder of the cell would be unaffected.

Neither the geomembrane nor the drains are likely to function, as initially placed, for 1,000 year or more. The geomembrane will deteriorate and cease to function, and the drains may eventually collapse or clog. Leachate may collect in the bottom of the cell and seep from the disposal cell. This seepage will be intercepted by the 3-ft-thick compacted clay liner which has a permeability of 10^{-7} cm/s or less. Seepage that migrates through the clay liner must also traverse at least 20 ft of unsaturated low-permeability soils having permeabilities of less than 10^{-7} cm/s (the vadose zone) prior to reaching the water table aquifer. The low permeabilities of these soil layers will severely inhibit migration of this seepage (values of less than 1 gpad were calculated in Section 8.5). In the course of downward migration, geochemical processes will significantly alter the chemistry of the seepage. Sorption and precipitation reactions in the clay liner and the foundation soils will play an important role in attenuating contaminants, thus minimizing their transport to the water-table aquifer below. If necessary, the clay liner can be thickened beneath low points in the cell where leachate may collect. This will be evaluated with hydrologic or geochemical models.

Channelization of seepage through the disposal cell and foundation may prevent full benefit of geochemical properties and effects. Incorporation of thick natural and engineered barriers (foundation soils and liners) should mitigate this potential.

Side slope rock will be placed in a configuration that discourages plant growth. Routine maintenance will include removal of vegetation that grows in the rock side slope of the clean-fill dike. If, however, routine maintenance is not performed (particularly in the long term after cessation of institutional controls), vegetation may gradually establish through the rock on the side slopes of the clean-fill dike. Toppling of trees would result in disruption of the riprap layers, but no waste would be exposed because it is not present below the side slope. The gullying potential would be increased because the rock armor would be disrupted, but significant headcutting would be minimized by the adjacent, undisturbed rock.

8.6.1.3 Stability. The failure scenario with the highest probability of occurring is a sustained drought that causes vegetation distress with a resulting reduction of resistance to storm water runoff. Under severe drought conditions, areas where vegetation has died will be more susceptible to erosion. The dead plant roots will provide some reinforcement of the soil, as will the gravelly rooting media. Beyond that, erosion will occur during a storm event of sufficient magnitude. Gullies may develop that reach the biointrusion layer, which will offer more resistance to erosion than the bare soil. This resistance should be sufficient until vegetation can

reestablish itself on the top slope. The design will function as planned even with a relatively poorly vegetated coverage.

It is highly unlikely that storm events or other natural forces such as earthquakes will disturb the disposal cell, since the design considers the impact of forces caused by such events. However, materials may degrade over time, which could lead to erosive forces that exceed the limits the degraded materials can withstand. Degradation could take the form of gullies developing in the top slope cover, decomposition of rock placed as riprap on the side slopes, and gullies cutting into the cell from advancement of off-cell drainage-ways. All of these possibilities are anticipated and considered in design (Ref. 134). Many subtle design features contribute to the ability of the cell to resist erosion. These details include providing a thickened cover or clean-fill dike near the break in slope from top to side where the potential for erosion is greatest, to isolate the waste further from the surface of the cell; oversizing the rock to account for potential degradation with time; and transitioning of the rock onto the top slope from the side slope to prevent rilling and gully initiation at the slope break.

8.6.1.4 Deformation. Figure 8-8 shows the potential effect of unanticipated extreme deformation on the cover. The design and construction features that preclude such deformation are noted on the figure. Exposure of the waste is highly unlikely. Even in the extreme event of failure, an increase in seepage and radon emissions is unlikely. By controlling the placement compaction density of the soils used to build the clean-fill dikes, deformation of the dikes will not cause performance difficulties. The potential for differential settlement between the waste and the dike soils are accommodated in the design.

8.6.2 Monitoring

The disposal cell performance assessment is the basis for establishing cell performance monitoring procedures. The various zones of monitoring and types of monitoring systems are considered in *Supporting Study 4B, Disposal Facility Hydrological Performance Monitoring* (in progress) (Ref. 103). Points of monitoring that were considered include the vapor flux rate through the cap, the drain above the infiltration barrier, the leachate collection system, and the leak detection system. Monitoring the groundwater below the cell was also considered. The type of monitoring system considered to be the best available technology is also recommended. It should be noted that monitoring system technology is evolving rapidly, and reassessment of this topic during final design is recommended in Study 4B (Ref. 103). However, if monitoring

of the cover is required, a single monitoring system, similar to the leak detection system planned for the base of the disposal cell, would be installed below the infiltration barrier. Such a system would require a separate radon barrier below it.

It is necessary to distinguish between monitoring the performance of the cell and monitoring for failure of the cell. Monitoring cell performance is not considered practical because the expected performance range yields very low moisture fluxes at the locations where monitoring can be performed. While instrumentation to detect such small fluxes is available, it is fairly unreliable for anything but very short durations and is invasive, requiring wires and tubes to penetrate critical layers which could provide pathways of moisture migration. Promising technologies for noninvasive monitoring techniques are being developed but currently are in the research stage.

Monitoring for failure of the disposal cell or its components is only practicable for fluxes and flows well in excess of those predicted for performance. Current technology relies on layers of sand (drains) to pick up leaks in liners placed above the drain layer. This technology appears to be practical for flows of 100 gpad, based on the EPA's minimum technology requirement (Ref. 65). Leaks as low as 2 gpad have been detected using this technology (Ref. 136). It is concluded that, for the disposal cell, it would be possible to detect leaks in the range of 2 gpad to 100 gpad. Detection of the less than 1 gpad expected for the cell operating conditions is not practicable at this time.

Cover failure conditions that could result in detectable seepage rates include significant loss of vegetation and large breaches in the cover system. Such defects are observable at the surface and would be repaired under normal maintenance, without the need for a leak detection system.

Failure of the liners at the base of the cell may not be reflected by visible distress at the cell surface. The liner and leachate collection systems provide a means of monitoring the waste contained in the cell at a location above the groundwater table. Thus, the separation of contaminants within the encapsulated waste from the existing groundwater contamination. Section 5.2.5 discusses details of the double leachate collection system.

8.7 Summary of Chemical Waste Management of Kansas Leachate Collection and Detection System Discharge

Bonneparte and Gross (Ref. 136) indicate that cells constructed using adequate quality control performed consistently better than others. A good example is the above-ground disposal Cell No. 2., part of the Chemical Waste Management of Kansas (CWMK) facility located near Furley, Kansas. The design of the 2.78-acre cell is similar to the proposed on-site disposal cell. The CWMK cell contains cement- solidified and stabilized sludges. Data on the volume of leachate have been collected since the cell was closed in November of 1989. These data provide some insight into how the on-site disposal cell would operate. The leachate collection and detection system data obtained from the EPA Region VII office in Kansas City, Kansas, are discussed below.

8.7.1 Cell Description

The waste footprint of Cell No. 2 covers 2.78 acres. The cell was constructed above grade and measures about 42 ft from the top of the cover to the bottom of the leachate collection and detection system (Figure 8-9). The cover is about 3.75 ft thick and slopes away from the center of the cell at a 10-to-1 slope. The cover construction is shown in Figure 8-10.

The liner is composed of primary and secondary leachate collection systems and a leak detection system. The liner construction is shown in Figure 8-10. There is an HDPE liner at the base of the primary and secondary liners that extends up the sides of the cell to the cover. An HDPE liner is also in place at the base of the leak detection system, but it does not tie into the cover, the leak detection system is open to the clean-fill dike. The cover does not extend over the clean-fill dike.

The clay liners were placed at moisture contents of about 27%. The degree of compaction was about 99% of maximum dry density. Laboratory tests indicated that the hydraulic conductivity was as low as 6.0×10^{-9} cm/s, compared with the design value of 1×10^{-7} cm/s.

The primary and secondary systems drain to internal sumps are designated as measuring points CPA-1 and CPA-2. The leak detection system drains to a sump outside of the cell, referred to as CPA-3.

The cell was ready to accept waste in December 1987; disposal of stabilized sludge began in April 1988 and was completed in July 1988. The cover was completed in November 1988.

8.7.2 Leachate Collection Data

Records of the quantity of leachate collected were obtained for January 1989 through December 1990. The data represent the quantity of liquid removed from the leachate collection and leak detection system, not the rate that leachate collected in the sumps. Leachate was removed as needed to meet a regulatory requirement of less than 1 ft leachate in the primary leachate collection system. The data are summarized in Table 8-3.

Reported monthly removal from the primary collection system varied from as high 10,000 gal to no recordable drainage. The total discharge for the period was 34,048 gal. Much less leachate was removed from the secondary collection system, only 22 gal for the period. Leachate collected from the leak detection system was 477 gal.

Because the reported data represents the quantity of leachate removed from the sump and not the flow into the sump, the reported data were smoothed using a three month moving average. Data for each month and the following two months were averaged and used to make Figure 8-11. Figure 8-11 suggests there was an increase in the leachate removed from the primary system in February 1990 from 0 in. in August 1990 after an initial decline following cell closure. Figure 8-12 shows that leachate from the secondary system and the leak detection system starts out high and diminishes rapidly to zero.

Monthly precipitation data is summarized in Table 8-3. Precipitation varied from a high of 8.88 in. in August 1989 to a low of 0 in. in November 1989.

8.7.3 Review Findings

In general, the volume of leachate removed rapidly declined after cell closure. The source of most of the leachate is probably water placed with the waste or the liner components during construction. The water is forced out of the clay components by consolidation and gravity drainage. Consolidation drainage is consistent with the shape of the drainage curves for the secondary system and the leak detection system. More leachate flowed from the leak detection

system than from the secondary collection system because the clay liner is twice as thick and is open to the clean-fill dike.

However, drainage from the primary collection system appears to have an additional component that is not consistent with consolidation drainage. An increase in drainage in 1990 indicates that part of the drainage may be infiltration through the cover and the waste.

The initial portion of the drainage curve through about November 1989 probably indicates construction water and consolidation drainage. However, the curve peaks again during February of 1990, about 13 months after closure. The source of water for the second peak could have been infiltration through the cover. The drainage peak lags behind the peak precipitation in August 1989 by 6 months. This was enough time for cover infiltration to percolate through the waste. About 3,133 gal of leachate were collected during 1990. The cover used an HDPE liner with a hydraulic conductivity of 1×10^{-11} cm/s, which should have limited the infiltration to about 2 gal/year. Therefore, the source of the leachate is probably not infiltration, unless there is a leak in the cover system.

Another potential source of the increase in leachate from the primary system is delayed drainage of construction water caused by the capillary break between the waste and the drainage layer. There is probably a large difference between the permeability of the waste and the drain material. It would require some time for the hydraulic head in the waste to build up to a point where the capillary forces at the contact between the waste and the sand drain could be overcome. There would be no flow until the head reaches a critical value. Once the supply of water in the waste is diminished, the flow would gradually decrease. The capillary break would explain the second peak in the leachate; however, it would require several more years of leachate collection data to confirm this hypothesis.

The increase in leachate in 1990 could also result from the method of leachate removal and reporting. During some months no leachate was removed from the primary leachate collection sump; however, this does not mean that leachate did not collect in the sump. The leachate was removed only as required by the regulatory requirements governing the operation of the cell.

The CWMK disposal represents a successful disposal cell design and implementation. The cover system and leachate collection and detection system designs are similar to those proposed for the Weldon Spring disposal cell, thus similar results should be expected. The leachate at the

Weldon Spring on-site disposal cell should be similar to the quantity and temporal distribution at the CWMK cell. The leachate data for the CWMK disposal cell demonstrates the complex nature of the moisture flux through the cell.

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9 SITE OPERATION AND DESIGN SYSTEM ANALYSIS

9.1 General

System analysis includes evaluating project completeness, sequence of activities, and interface compatibility. The complex issues, activities, and designs related to the remediation program require the analysis of these as they relate to the entire system. Designs presented in Sections 5 and 6 were analyzed to show how a particular design fits into other activities. Each design has a system analysis segment incorporated into Sections 5 and 6. This section deals with some of the overall concepts of the system.

9.2 Project Completeness

With the exception of groundwater remediation, the site conceptual design encompasses all remediation activities at the Weldon Spring Chemical Plant site. Previous interim response actions (such as building dismantlement and demolition), and the temporary storage of materials removed from the quarry, were carried out under the *Record of Decision for the Management of Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (ROD) (Ref. 138). The conceptual design provides for the final disposal of these materials from previous actions, along with the treatment and disposal of remaining wastes at the chemical plant site.

Activities associated with the cleanup include constructing permanent and temporary facilities and a multitude of infrastructure systems; including support systems such as roads, water transport systems, and utilities. These activities must be carried out in a safe and healthy manner to minimize the impact of remediation on the environment, and to provide safe working conditions for personnel.

The relatively small size of the site complicates logistics. Slightly more than 200 acres will house large temporary storage areas (the material storage area [MSA], the temporary storage area [TSA], and the Ash Pond spoils area), waste and water treatment plants, construction support areas water storage and control points, as well as a disposal cell that could reach 0.5 mi in length. Construction activities, excavation of contaminated soils and stockpiled materials, monitoring of work, and transport of clean materials all require mobilization of equipment and materials within a confined area. Real estate is at a premium.

The engineers who developed the conceptual designs presented in the previous sections were challenged to develop their concepts in close communication with each other. Locations of the components had to be carefully fitted into the existing complex. Title II designers will need to continue looking at the project from an overall perspective rather than task by task or design by design.

9.3 Interface Compatibility

The interfaces associated with the remedial activities are numerous. Before the building foundations can be excavated, certain activities must take place, such as construction of retention and sedimentation ponds and a construction material staging area (CMSA) for storage of clean soil excavated during removal of the foundations, site preparation of Ash Pond, development of the borrow area, and construction of a haul road to transport borrow to the site. A network of clean and dirty roads will be utilized and trucks coordinated to transport materials for all of these construction activities.

Following building foundation removal, construction will begin on the chemical stabilization/solidification (CSS) treatment plant and the disposal cell. After the first phase of cell construction, waste placement and excavation of contaminated material interact continually. Dredged material from the raffinate pits will be transitioned through dewatering to the CSS plant where the product is then transported to the disposal cell to be poured or compacted over building rubble previously transported from the MSA, TSA, and Ash Pond. While waste placement is progressing in Phase I, construction will continue in Phase II.

In order to coordinate all of these activities, the designers developed workable scenarios and interactions. Sequencing became a critical part of the operations in Section 6, as well as in the scheduling discussed in the *Cost and Schedule Document*. Production rates of treatment plant components and waste placement schemes also affected designs developed in Section 5.

Water management and the transport of reagents, borrow material, and personnel were identified during the conceptual design process as major areas for further study once the sequence of activities is defined by the cost and scheduling document.

Title II design will continue the process of system analysis to coordinate designs and operations such that each phase can transition smoothly to the next.

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10 OUTLINE OF SPECIFICATIONS

10.1 General

The format and type of specifications for the Weldon Spring site remediation are described in this chapter. According to the Weldon Spring Site Remedial Action Project (WSSRAP) procedure for preparing specifications (Ref. 45), the Construction Specification Institute (CSI) format will be used in developing the specifications during Title II design. Of the two types of specifications, prescriptive (design) and performance, prescriptive specifications will be used for most of the site remediation. Performance specifications specifying ends or results may be used for treatment of certain wastes stored in Building 434.

10.2 Basis of Outline

The outline of the specifications contained in this section is a culmination of specifications relating to each design element described in Sections 5 and 6. The four broad areas of design are site design, disposal facility, waste treatment and processing, and site closure/long-term monitoring and maintenance. Each of the four areas of design are further broken into more specific elements (Section 5 subsections) of the site remediation as follows:

I. Site Design (5.1)

- Waste Removal (5.1.2)
- Waste Handling and Transportation (5.1.3)
- Construction Material Staging Area (5.1.4)
- Site Roads (5.1.5)
- Site Drainage (5.1.6)
- Borrow Materials (5.1.7)
- Other Facilities (5.1.8)

II. Disposal Facility (5.2)

- Cell Siting (5.2.2)
- Configuration/Optimization (5.2.3)
- Foundation (5.2.4)

- Liner/Leachate Collection and Removal Systems (5.2.5)
- Waste Placement (5.2.6)
- Waste Containment System (5.2.7; Cover/Clean Fill Dikes)
- Cell Drainage/Water Management (5.2.8)
- Operation and Maintenance (5.2.9)

III. Treatment and Processing (5.3)

- Chemical Stabilization/Solidification (5.3.2)
- Vitrification (5.3.3)
- Size Reduction (5.3.4)
- Dewatering (5.3.5)
- Decontamination (5.3.6)
- Additional Treatments (5.3.7)

IV. Site Closure (5.4)/Long-Term Monitoring and Maintenance (5.5)

10.3 Outline of Specifications

Listed below is an outline of specifications, in CSI format, taken from additional assessment reports and Section 5. The outline is based upon the assumption that chemical stabilization/solidification (CSS) will be the method of treatment for raffinate sludge and contaminated soil, and the specifications will all be of a prescriptive type. For Divisions 2 through 16, Section 5 subsection numbers are given as a guide to the specific design elements of the site remediation, which should be considered as the specifications are developed, but not limited to the following.

<u>Division</u>	<u>Section</u>
1. General	01010 Summary of Work
Requirements	01025 Measurement and Payment
	01060 Regulatory Requirements
	01065 Safety and Health
	01070 Abbreviations and Symbols
	01201 Preconstruction and Prewrite Meetings

01202 Progress Meetings
 01300 Submittals
 01310 Contractor Prepared Network Analysis System
 01400 Construction Quality Assurance and Quality Control
 01420 Chemical Quality Assurance and Quality Control
 01500 Temporary Facilities and Utilities
 01540 Site Security
 01560 Temporary Controls
 01570 Traffic Routing and Regulations
 01580 Project Identifications and Signs
 01700 Project Closeout

Division	Section	Related Section 5 Subsections
2. Site Work	02010 Drilling, and Monitoring Well Installation and Abandonment	5.4/5/5
	02050 Demolition/ Dismantlement and Debris Disposal	5.1.2, 5.1.3, 5.1.4, 5.2.6
	02110 Clearing and Grubbing	5.1.4, 5.1.5, 5.1.6, 5.1.7, 5.2.4, 5.2.7
	02130 Contaminated Solids, Contaminated Liquid, and Incidental Waste Excavation/Removal, Handling, Sorting, and Stockpiling	5.1.2, 5.1.3, 5.2.4, 5.3.2, 5.3.6, 5.3.7
	02180 Placement of Contaminated Solids in the Disposal Facility	5.2.6
	02210 Site Grading, Excavation, Filling, and Backfilling	5.1.4, 5.1.5, 5.1.6, 5.1.7, 5.1.8, 5.2.4, 5.2.7, 5.2.8, 5.4

Division	Section	Related Section 5 Subsections
	02221 Excavation, Trenching, and Backfilling for Utilities	5.1.4, 5.1.8, 5.3.7, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4
	02232 Graded-Crushed-Aggregate Course	5.1.4, 5.1.5, 5.1.8, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4
	02271 Riprap	5.2.7
	02410 Liners, Leachate Collection, and Leak Detection Layers	5.2.5
	02420 Site Surface Drainage and Detention Basins	5.1.6
	02444 Chain Link Fences and Gates	5.1, 5.4
	02480 Natural Cover Components of Disposal Facility	5.2.7
	02500 Paving and Surfacing	5.1.5, 5.1.8, 5.4
	02700 Pipe Utilities	5.1.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
	02765 Geosynthetic Drainage Net	5.2.5
	02770 Geotextile	5.2.5
	02775 Geomembrane	5.2.5, 5.2.7
	02780 HDPE Pipe	5.2.5
	02800 Power and Communication Utilities	5.1.4, 5.1.8, 5.2.9, 5.3.2, 5.4/5.5

Division	Section	Related Section 5 Subsections
3. Concrete	02881 Dredging of Raffinate Sludge	5.1.2, 5.3.5
	03300 Cast-In-Place Concrete	5.1.4, 5.1.6, 5.1.8, 5.2.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4
	03361 Shotcrete	5.1.3
4. Masonry	Not Used	
5. Metals	05100 Structural Metal Framing	5.3.2
	05300 Metal Decking	5.3.2, 5.3.5, 5.3.6, 5.3.7
	05500 Metal Fabrications	5.1.8, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7
6. Wood and Plastic	06100 Rough Carpentry	5.1.4, 5.1.8, 5.2.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7
	06500 Prefabricated Structural Plastic	5.1.4, 5.1.8, 5.2.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4
	06600 Plastic Fabrications	5.1.4, 5.1.8, 5.2.5, 5.2.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4
	07100 Waterproofing	5.1.8, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4
7. Thermal/Moisture Protection	07200 Insulation	5.1.8, 5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4
	07250 Fireproofing	5.1.8, 5.3.2, 5.3.4, 5.3.6, 5.3.7, 5.4
	07400 Preformed Roofing and Siding	5.1.8, 5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4
	07900 Sealants	5.1.8, 5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4

Division	Section	Related Section 5 Subsections
8. Doors and Windows	08100 Doors, Frames, and Windows	5.1.8, 5.3.2, 5.3.6, 5.3.7, 5.4
	08700 Hardware and Glazing	5.1.8, 5.3.2, 5.3.6, 5.3.7, 5.4
9. Finishes	09900 Painting	5.1.8, 5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4
10. Specialties	10150 Compartments and Cubicles	5.1.8, 5.3.2, 5.3.6, 5.3.7
	10520 Fire Extinguishers	5.1.4, 5.1.8, 5.2.6, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
	10530 Protective Covers	5.1.8, 5.2.9, 5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
	10650 Scales	5.1.7, 5.2.6, 5.2.9, 5.3.2, 5.3.5, 5.3.7
	11300 Sludge Flocculation, Settling, Thickening, and Dewatering	5.1.2, 5.3.5
11. Equipment	11330 Chemical Solidification/Stabilization	5.3.2
	11360 Radon Emission Controls	5.1.2, 5.1.3, 5.2.6, 5.2.9, 5.3.2, 5.3.5, 5.3.7
	Not Used	
12. Furnishings		
13. Special Construction	13120 Pre-Engineered Structures	5.1.4, 5.1.8, 5.2.8, 5.2.9, 5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
	13140 Decontamination Facilities	5.1.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4

Division	Section	Related Section 5 Subsections
14. Conveying Systems	14500 Material Handling Systems	5.1.2, 5.1.3, 5.1.4, 5.1.7, 5.2.6, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.5
15. Mechanical	15400 Plumbing Systems	5.1.4, 5.1.6, 5.1.8, 5.2.8, 5.2.9, 5.3.2, 5.3.5, 5.3.6, 5.4/5.5
	15500 Fire Protection	5.1.8, 5.3.7, 5.4/5.5
	15900 Controls and Instrumentation	5.1.8, 5.2.9, 5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
16. Electrical	16050 Basic Materials and Methods	5.1.4, 5.1.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
	16400 Service and Distribution	5.1.4, 5.1.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
	16500 Lighting	5.1.4, 5.1.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5
	16600 Special Systems	5.2.3, 5.3.5, 5.3.6, 5.3.7
	16700 Communications	5.1.8, 5.2.9, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.3.7
	16900 Controls and Instrumentation	5.3.2, 5.3.5, 5.3.6, 5.3.7, 5.4/5.5

As the site remedial design progresses from Title I through Title II, the outline and content of the specifications will require constant reevaluation and change by the designers. The outline will significantly change because of information obtained through additional bench and pilot scale testing, waste and site characterization, contracting strategy, and method of specification (i.e., prescriptive or performance).

For example, additional containerized waste characterization and bench testing may indicate that additional treatments (Chapter 5, Subsection 5.3.7) should be through performance specifications, given the wide variety and potential need for off-site treatment (i.e., incineration).

Also, the likelihood that the site remediation will consist of more than one contract (e.g., separate treatment and disposal construction contracts) will result in some of the specification sections listed above being modified or deleted.

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11 REMEDIAL DESIGN WORK PLAN

11.1 General

The remedial design work plan represents a logical, integrated sequence of events that progresses from the conceptual design through detailed planning and design activities, and finally to procurement of subcontracts to execute the remedial action. Design activities will incorporate concepts such as cost consciousness and value engineering to facilitate effective and efficient construction and operation of a particular design component. Elements of this plan are listed on the table below.

Element	DESCRIPTION
Work package construction plan	Includes a summary of recommended subcontract packages required to complete the proposed remedial action.
Quality assurance compliance	Details quality assurance considerations, including applicable references.
Design schedule	Includes a listing of design tasks, noting related schedules and durations.
FFA submittals	Provides a summary of the scope for document submittals required in the WSSRAP FFA.
Procurement activities	Provides a summary of procurement options, including guidance on the application of these options.

The Weldon Spring Site Remedial Action Project (WSSRAP) *Federal Facilities Agreement* (FFA) (Ref. 140) requires the U.S. Department of Energy (DOE) to submit a *Remedial Design Work Plan* to regulators as a primary deliverable. This deliverable must include a design schedule, a detailed description of the design activities, enforceable deadlines for other post-*Record of Decision* (ROD) primary deliverables, and target dates for post-ROD secondary documents.

Detailed subcontracting information developed during the conceptual design process for the Chemical Plant Operable Unit is included with the *Cost and Schedule Document* (CSD). Summaries of the CSD information are presented in this chapter, and the proposed design activities and schedules are based upon the CSD.

11.2 Work Package Construction Plan

Work packages for the remedial action are summarized by title and sequential work package number in Table 11-1. These work packages represent the major operations required to remediate the Chemical Plant Operable Unit. Detailed logic and discussions of remedial operations are presented in Section 6. Detailed scheduling information is presented in the CSD.

11.3 Quality Assurance Compliance

All activities at the WSSRAP are conducted under specified quality assurance requirements. These requirements are implemented by specific departments with the direction and coordination of the Project Quality Department. Quality levels vary depending on the economic cost and risk posed by the activity using the graded approach. In summary, this approach requires an increasing level of quality assurance measures for activities that pose greater cost and risk. Quality levels range from 1 - 3, with quality Level 1 being the highest. Detailed descriptions of the quality assurance/quality control (QA/QC) organization and requirements are found in *Support Study 36, Remedial Action Quality Control Implementation* (Ref. 141). This document also includes recommended test methods and frequencies for each conceptual design component, identifies circumstances where either hold or witness points should be specified, and outlines resolution processes when test failures occur or testing trends indicate parameters are approaching unacceptable conditions.

11.4 Design Schedule

The design schedule includes relevant design milestones for the key work packages to be reviewed by regulators as required by the *Federal Facilities Agreement* (Ref. 140). The four primary work packages are: (1) Foundations and Soil Removal; (2) Pilot-Scale Chemical Stabilization/Solidification (CSS) Facility; (3) Full-Scale CSS Facility; (4) Disposal Cell Construction. The design schedule for key work packages is outlined on Table 11-2. Design schedule information for all other work packages is included in Table 11-1.

11.5 Federal Facility Agreement Post-Record of Decision Document Submittals

The WSSRAP FFA requires post ROD document submittals. These submittals are categorized as primary documents and secondary documents. A list of all FFA-required

deliverables and associated submittal schedules (including Engineering Design Reviews) is presented in Table 11-2. Specific milestone dates for FFA submittals will be prepared as a separate addendum to the *Conceptual Design Report* (CDR), and will be forwarded to regulators by March 1994.

Each of the post-ROD documents required in the FFA is summarized below. Some of the secondary documents are listed as "Not Applicable". In these cases, the scope and intent of the document is fulfilled elsewhere or does not apply to the chemical plant operable unit. In the latter case, the U.S. Department of Energy (DOE) recommends the requirement for these submittals be deleted.

- *Remedial Design Work Plan* (P Document): This submittal requirement is fulfilled by the CDR and *Technical Information Document* (TID), within the specific areas indicated below:
 - Design Schedule Deadlines for post-ROD "P" Documents: An outline of these submittals is presented in Table 11-2. Specific deadlines will be submitted as a separate addendum to the CDR.
 - Detailed Description of Design Activities: This information is included in Sections 5 and 6 of the TID.
- *Pre-Design Work Plan* (S Document): This document is not applicable to the Chemical Plant Operable Unit, and will not be submitted as an FFA-required deliverable. MK-Ferguson, the Project Management Contractor (PMC), will perform the remedial design. This eliminates the transfer of project information between the *Remedial Investigation/Feasibility Study* (RI/FS) to engineering contractors. However, a field sampling plan for additional characterization activities has been previously submitted to regulators.
- *Pre-Design Investigation Report* (S Document): This document is not applicable to the Chemical Plant Operable Unit, and will not be submitted as an FFA-required deliverable. The TID summarizes and/or references relevant information regarding pre-design investigations.

- **Treatability Studies (S Document):** The *Federal Facilities Compliance Act (FFCA)* requires site treatment plans for mixed wastes. The FFCA schedule for submitting treatment plans specifies that the DOE will provide treatment plans in three phases: a "conceptual plan" by October 1993; a "draft plan" no later than August 1994; and, a "final proposed plan" no later than February 1995. Other relevant sampling plans and treatability studies will be submitted in subsequent FFA quarterly reports.
- **Remedial Design Quality Assurance Program Plan (QAPP) (S Document):** This document will not be submitted as a specific FFA deliverable. The intent of this document is satisfied in existing WSSRAP documents, which are outlined in *Support Study 36, Remedial Action Quality Control Implementation* (Ref. 141).
- **Contingency Plan (S Document):** This document is not applicable to the Chemical Plant Operable Unit, and will not be prepared or submitted.
- **Construction Quality Control Plan:** This document will not be submitted as a separate FFA deliverable. The requirements of this plan are outlined in *Support Study 36, Remedial Action Quality Control Implementation* (Ref. 141). Construction quality control requirements for specific design submittals will be included with the design submittals.
- **Design Submittals (P and S Documents):** An outline of design submittals for the four primary work packages is provided in Table 11-1. Specific deadlines will be submitted as a separate addendum to the CDR.
- **Remedial Action Work Plan (P Document):** This document will be submitted following award of each final design packages and will include a construction schedule and names and background information on the subcontractors selected.
- **Pre-Final Inspection Report (S Document):** A single document will be prepared following this inspection. The pre-final inspection will be scheduled following verification of contaminant removal from all documented sources and before cell closure.

- *Construction Completion Report (P Document)*: The requirements for this document will be satisfied by the *Record of Completed Actions (ROCA) Report* for the Chemical Plant Operable Unit. A ROCA report will be prepared for each WSSRAP operable unit, as a PMC contract deliverable to the DOE.
- *Operations and Maintenance Plan (P Document)*: This document will be finalized after the pre-final inspection and will address any post-closure operations or maintenance required. These activities may include leachate collection/management, environmental monitoring, disposal cell performance monitoring, and routine maintenance.

11.6 Procurement

Procurement strategies are listed below. Following each specific strategy is a description of the process and recommendations for use, depending on subcontract requirements. All procurement packages should include basic components such as: scope and specifications, descriptive figures or engineering drawings, quality assurance and quality control requirements, health and safety requirements, and Federal contracting provisions.

Two-step procurement, with minimum qualifications: This process includes issuance of a set of minimum qualifications in order to screen bidders. All bidders who are found to qualify are then eligible to submit bids on the bid package. Award is based upon low bid of the qualified bidders. This process ensures that all prospective bidders have a minimum level of experience and/or competence.

Invitation for Bids (IFB): This process includes issuance of a bid package. Interested bidders then prepare bids based upon the requirements of the bid package. Award is based upon the apparent low bid.

Request for Proposal (RFP): This process involves the use of a series of ranking criteria. The ranking criteria are weighted, with cost included among the criteria. The award is based upon the top score among proposers, considering all criteria scores, multiplied by the weight of each criteria. Further, the RFP allows potential bidders to obtain clarification of technical items in the bid package prior to submission of a best and final proposal.

Purchase Order (PO): This process requires the preparation of a scope of work, noting specific items to be accomplished, and associated quality and health and safety requirements. This is normally used for subcontract activities that do not require field work, such as laboratory testing.

Non-Competitive Procurement: This approach may be used with either a purchase order or a work package, and requires justification of procurement of a specified subcontractor without competition. This justification must demonstrate the specified subcontractor has unique qualifications required to perform the subcontract task.

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DOE ORDERS

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| 4300.1C | <i>Real Property Management</i> |
| 4700.1 | <i>Project Management System</i> |
| 5400.1 | <i>General Environmental Protection Program</i> |
| 5400.5 | <i>Radiological Protection of the Public and the Environment</i> |
| 5440.1E | <i>National Environmental Policy Act Compliance</i> |
| 5480.1 | <i>Environmental Protection Safety and Health Protection Information Reporting Requirements</i> |
| 5480.4 | <i>Environmental Protection, Safety, and Health Protection Standards</i> |

5480.10	<i>Contractor Safety and Health Program</i>
5480.11	<i>Radiation Protection for Occupational Workers</i>
5632.6	<i>Physical Protection of DOE Property and Unclassified Facilities</i>
5700.6C	<i>Quality Assurance Program a Total Management System</i>
5820.2A	<i>Radioactive Waste Management</i>
6340.1A	<i>General Design Criteria</i>

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7 CFR 6.302(c)	<i>Farmland Protection Policy Act</i>
10 CFR 1021	<i>NEPA Implementing Procedures</i>
29 CFR	<i>Labor</i>
29 CFR 26, Subpart P	
29 CFR 1910	<i>Occupational Safety and Health Standards</i>
29 CFR 1910.95	<i>Occupational Noise Exposure</i>
29 CFR 1910.120	<i>Hazardous Waste Operations and Emergency Response</i>
29 CFR 1910.1000	<i>Air Contaminants</i>
29 CFR 1926	<i>Safety and Health Regulations for Construction</i>
40 CFR 61	<i>National Emission Standards for Hazardous Air Pollutants</i>
40 CFR 61, Subpart H	<i>National Emission Standards for Emissions of Radionuclides other than Radon for DOE Facilities</i>
40 CFR 61, Subpart Q	<i>National Emission Standards for Radon Emissions from DOE Facilities Radon Flux Standard</i>
40 CFR 61, Subpart T	
40 CFR 61.192	<i>(Subpart Q) Standard</i>
40 CFR 122	<i>EPA Administered Permit Programs: The National Pollutant Discharge Elimination System</i>
40 CFR 192, Subpart D	<i>Standards for Management of Uranium By-Product Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended</i>
40 CFR 192, Subpart A	<i>Standards for the Control of Residual Radioactive Materials From Inactive Uranium Processing Sites</i>
40 CFR 192, Subpart B	<i>Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites</i>

40 CFR 192.02(a)	<i>Standards</i>
40 CFR 192.02(b)(1)	<i>Standards</i>
40 CFR 192.02(b)(2)	<i>Standards</i>
40 CFR 258	<i>Criteria for Municipal Solid Waste Landfills</i>
40 CFR 260	<i>Hazardous Waste Management System: General</i>
40 CFR 262	<i>Standards Applicable to Generators of Hazardous Waste</i>
40 CFR 264, Subpart G	<i>Surface Impoundment - Closure and Post-Closure Use and Management of Containers</i>
40 CFR 264, Subpart I	<i>RCRA Storage Requirements</i>
40 CFR 264	<i>Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities</i>
40 CFR 264.18	<i>Location Standards</i>
40 CFR 264.18, Subpart A	<i>General</i>
40 CFR 264.18, Subpart B	<i>General Facility Standards</i>
40 CFR 264.18, Subpart C	<i>Preparedness and Prevention</i>
40 CFR 264.18, Subpart F	<i>Releases from Solid Waste Management Units</i>
40 CFR 264.90	<i>Applicability</i>
40 CFR 264.95	<i>Point of Compliance</i>
40 CFR 264.98	<i>Detection Monitoring Program</i>
40 CFR 264.111	<i>Closure Performance Standard</i>
40 CFR 264.178	<i>Closure</i>
40 CFR 264.192	<i>Design and Installation of New Tank Systems or Components</i>
40 CFR 264.193	<i>Containment and Detection of Releases</i>
40 CFR 264.194	<i>General Operating Requirements</i>
40 CFR 264.228	<i>Surface Impoundments - Closure and Post-Closure Care</i>
40 CFR 264.228	<i>Closure and Post Closure Care - (k) Surface Impoundments</i>
40 CFR 264.258	<i>Closure and Post Closure Care - (l) Waste Pile</i>
40 CFR 264.301	<i>Design and Operating Requirements</i>
40 CFR 264.310	<i>Closure and Post-Closure Care</i>
40 CFR 264.314	<i>Special Requirements for Bulk and Containerized Liquids</i>
40 CFR 266, Subpart H	<i>Hazardous Waste Burned in Boilers and Industrial Furnaces</i>
40 CFR 266.104	<i>Standards to Control Organic Emissions</i>
40 CFR 268	<i>Land Disposal Restrictions</i>
40 CFR 268, Subpart C	<i>Prohibitions on Land Disposal</i>

40 CFR 761	<i>PCBs Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions</i>
40 CFR 761, Subpart D	<i>Storage and Disposal</i>
40 CFR 761.60	<i>Disposal Requirements</i>
40 CFR 761.70	<i>Incineration</i>
40 CFR 761.75(b)(3)	<i>Hydrologic Conditions</i>
49 CFR	<i>Transportation</i>

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10 CSR 10-5.050	<i>Restriction of Emission of Particulate Matter from Industrial Processes</i>
10 CSR 10-5.090	<i>Restriction of Emission of Visible Air Contaminants</i>
10 CSR 10-5.180	<i>Emission of Visible Air Contaminants from Internal Combustion Engine</i>
10 CSR 10-5.310	<i>Liquified Curb Asphalt Paving Restricted</i>
10 CSR 10-6.010	<i>Ambient Air Quality Standards</i>
10 CSR 10-6.060	<i>Permits Required</i>
10 CSR 10-6.170	<i>Restriction of Particulate Matter to the Ambient Air Beyond the Premises of Origin</i>
10 CSR 20-8.200	<i>Wastewater Treatment Ponds (Lagoons)</i>
10 CSR 25-7.264	<i>Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities</i>
10 CSR 25-11.010	<i>Waste Oil</i>
10 CSR 40-10.010	<i>Permit Requirements for Industrial Mineral Operations</i>
10 CSR 40-10.050	<i>Performance Requirements</i>
10 CSR 80-3.010	<i>Solid Waste Management Sanitary Landfill Design and Operation</i>
19 CSR 20-10.040	<i>Maximum Permissible Exposure Limits</i>
19 CSR 20-10.090(1)	<i>Disposal of Radioactive Wastes</i>

PROCEDURES

ES&H 4.1.1a	<i>Numbering System for Environmental Samples and Sampling Locations</i>
ES&H 4.1.2s	<i>Chain of Custody</i>
ES&H 4.1.3s	<i>Sampling Equipment Decontamination</i>

ES&H 4.4.1s	<i>Groundwater Sampling</i>
ES&H 4.4.2s	<i>Groundwater Level Monitoring and Well Integrity Inspections</i>
ES&H 4.5.1s	<i>pH and Temperature Measurements in Water</i>
ES&H 4.5.2s	<i>Specific Conductance Measurement in Water</i>
ES&H 4.5.8s	<i>Water Sample Filtering</i>
ES&H 4.5.6s	<i>Measurement of Dissolved Oxygen in Water</i>
ES&H 4.5.10s	<i>Alkalinity Measurements in Water</i>
RC-15a	<i>Waste Minimization Feasibility Analysis</i>
RC-30s	<i>Disposal of Purge and Development Water from Groundwater Monitoring Wells</i>

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